National Urban Air Quality Trends 1974 to 1985

Report EPS 7/UP/2
May 1987

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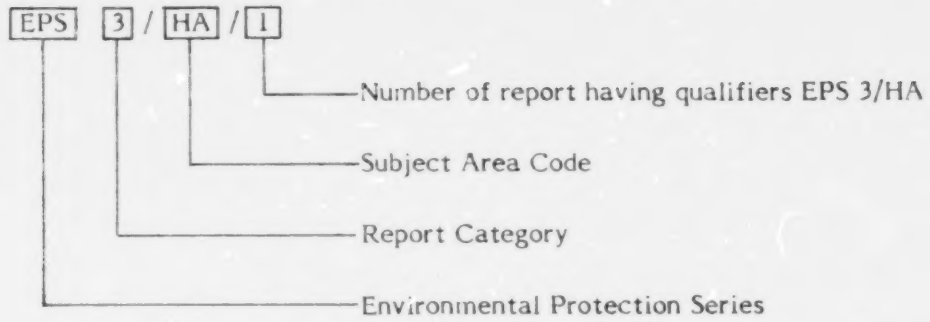
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NATIONAL URBAN AIR QUALITY TRENDS 1974-1985

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Report EPS 7/UP/2
May 1987

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ABSTRACT

The air quality data analysed in this report come from the National Air Pollution Surveillance (NAPS) monitoring network, which consists of air monitoring stations in most Canadian cities with populations of over 100 000. The periods for which valid national data are available and the contaminants considered are:

Sulphur dioxide, 1974 - present
Nitrogen dioxide, 1977 - present
Carbon monoxide, 1974 - present
Ozone, 1979 - present
Suspended particulate, 1974 - present
Lead, 1974 - present
Soiling index, 1974 - present

Monitoring data have been analyzed to determine trends in national average annual concentrations of these contaminants. Data have also been compared with the National Ambient Air Quality Objectives which define three levels of contaminant concentration:

1) Maximum Desirable - defines the long-term goal for air quality which provides a basis for an anti-degradation policy for the unpolluted parts of the country and for the continuing development of control technology;

2) Maximum Acceptable - is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort, and well-being; and

3) Maximum Tolerable - denotes a concentration of an air contaminant that requires abatement without delay to avoid further deterioration to an air quality that endangers the prevailing Canadian lifestyle or, ultimately, to an air quality that poses a substantial risk to public health.

These levels are defined for various contaminants at various concentrations for different periods of exposure.

The NAPS data represent pollution levels at individual sampling sites and may not necessarily represent community-wide air quality. Community-wide comparisons can only be made using data from all available sampling stations within a city, and interpreting these data on the basis of specific sampling and site characteristics.

Mean concentrations have been derived as arithmetic means for all contaminants except suspended particulate matter and particulate lead, where geometric means have been used.

In an effort to compare data that are representative of annual conditions, since completeness criteria were first applied to the NAPS data in 1974, data used for analysis in this report span the period 1974 to 1985.

RÉSUMÉ

Les données sur la qualité de l'air analysées dans ce rapport proviennent du Réseau national de surveillance de la pollution atmosphérique (RNSPA). Ce réseau exploite des stations de surveillance dans la plupart des villes canadiennes de plus de 100 000 habitants. Les polluants pris en considération sont l'anhydride sulfureux (ou dioxyde de soufre), le dioxyde d'azote, le monoxyde de carbone, l'ozone, les particules en suspension, ainsi que le plomb et nous analysons également la tendance de l'indice de souillure. Nous indiquons ci-dessous l'année à partir de laquelle les données recueillies par le RNSPA sont considérées valables à la grandeur du pays:

Anhydride sulfureux - 1974
Dioxyde d'azote - 1977
Monoxyde de carbone - 1974
Ozone - 1979
Particules en suspension - 1974
Plomb - 1974
Indice de souillure - 1974.

Les données du RNSPA ont été analysées pour déterminer l'orientation dans le temps des teneurs annuelles moyennes pour les polluants d'intérêt et l'indice de souillure et nous les avons aussi comparées aux objectifs nationaux de qualité d'air ambiant (ONQAA). Ces objectifs comportent trois niveaux de qualité:

1) La teneur maximale souhaitable est un objectif à long terme de la qualité de l'air. C'est sur elle que s'appuie toute politique visant à prévenir la dégradation des régions de notre pays non touchées par la pollution. Les divers moyens de lutte contre la pollution atmosphérique doivent tendre à circonscrire la pollution à la teneur maximale souhaitable.

2) La teneur maximale acceptable vise à protéger le sol, l'eau, la végétation, les matériaux, les animaux, le mode de vie et le bien-être de la population contre les effets néfastes de la pollution, et à prévenir une réduction de la visibilité.

3) La teneur maximale admissible nécessite une action immédiate faute de quoi la pollution atmosphérique pourrait menacer le mode de vie de la population exposée ou à long terme constituer une menace pour la santé. Elle correspond au niveau d'intervention.

Les objectifs fixés pour les polluants correspondent à des teneurs définies pour des périodes définies.

Le lecteur notera que la qualité de l'air échantillonné à une station du RNSPA représente la qualité de l'air dans le voisinage immédiat de la station et pas nécessairement la qualité de l'air de toute la région urbaine. Pour faire des comparaisons de grandeur entre agglomérations, les données de toutes les stations d'échantillonnage d'une ville devraient donc être utilisées et ces données devraient être interprétées selon les particularités propres à l'échantillonnage et à l'emplacement des stations.

Les teneurs moyennes sont exprimées en moyennes arithmétiques, excepté pour les particules en suspension et le plomb, pour lesquels on a utilisé les moyennes géométriques.

Depuis 1974, les résumés annuels du RNSPA ne tiennent compte que des moyennes mensuelles, annuelles ou géométriques qui répondent aux critères de complétude des données établis pour chaque polluant, ce qui explique pourquoi cette analyse des tendances exclut les années antérieures à 1974.

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SUMMARY

The National Air Pollution Surveillance (NAPS) network, responsible for monitoring the quality of air, has undergone many refinements since its inception in 1970. Since the mid-seventies, the NAPS network has attained the size needed to show geographic and periodic variations in national air quality. The quality of the air is defined according to the National Ambient Air Quality Objectives: desirable, acceptable, and tolerable. The "acceptable" level is based on protection of human health as well as visibility, animals, soil, water and vegetation.

Routine monitoring in urban areas from 1974 to 1985 shows considerable improvements in ambient air quality as can be seen in the table below:

NAPS NETWORK "REPORT CARD" ON ATTAINMENT OF NATIONAL AMBIENT AIR QUALITY OBJECTIVES FOR 1974 AND 1985

Pollutant	1985 Mean Levels		Percent Decline from 1974 level	Attainment Rate for Acceptable Level (%)							
				Annual		1 hour		8 hours		24 hours	
				1974	1985	1974	1985	1974	1985	1974	1985
SO_2	6	ppb	54	82	100	87	92	--	--	85	95
NO_2*	22	ppb	29	96	100	86	100	--	--	84	96
CO	1.0	ppm	58	--	--	97	98	71	94	--	--
O_3*	17	ppb	no trend	50	40	18	49	--	--	--	--
TSP	42.9	$\mu g/m^3$	45	51	98	--	--	--	--	--	--

* For NO_2 and O_3 the attainment rate is compared to 1977 and 1979 respectively.

It should be noted that the coefficient of haze and particulate lead are not covered under the National Ambient Air Quality Objectives and are therefore not shown in the table above. Since 1974, the coefficient of haze and particulate lead composite annual mean concentrations have shown declines of 25% and 74%, respectively. An improvement in the resolution of the summary statistics, used in this analysis of air quality trends, has resulted in a greater decline of the sulphur dioxide annual mean than previously reported.

This report also features data analysis techniques which assess the significance of changes in pollutant concentrations. For example, the average concentrations of the following pollutants have shown significant (at 99% confidence) improvement: sulphur dioxide, nitrogen dioxide, carbon monoxide, lead, and total suspended particulate. Coefficient of haze has shown a similar (at 95% confidence) decline, while ozone has shown no trend.

An excellent indicator of air quality is the "National Annual Air Quality Index" which has been calculated for all Class 1 Stations for the period 1977 to 1985. For 1985, as in past years, most sites registered in the "fair" category; however, thirteen sites registered in the "good" category, an increase of four over the 1983 results. Also, as in the previous report, no sites registered in the "poor" category for the years 1984 and 1985.

1 INTRODUCTION

1.1 Purpose and Scope

This is the sixth in a series of reports (1,2,3,5,6) on ambient air quality trends issued by Environment Canada. Its purpose is to report trends in the ambient air quality data collected through the National Air Pollution Surveillance (NAPS) Network (4) and to identify significant changes by statistical and other forms of analysis. Monitoring results cover the 1974-1985 year period.

The NAPS program was initiated in January 1970 to provide a nationwide data base for determining air quality in the major urban centres in Canada. Effects on the urban environment as a consequence of changing industrial activity, fuel use patterns, population density, more extensive use of pollution control equipment, and other factors are documented in the trends reports. Air monitoring stations are maintained in most Canadian cities having populations greater than 100 000. Monitoring instruments are usually located at sites where air pollution could present a problem and where a large number of people could be affected. These sites are referred to as "monitoring stations" and are classified according to the primary land use in their location:

C - Commercial,
R - Residential, and
I - Industrial.

Guidelines have been established categorizing NAPS stations as Class I and Class II. The "Class I" network is the permanent national network of comprehensive monitoring stations which are operated over the long term. These sites were selected to represent areas of highest population exposed to the prevailing air quality. The "Class II" stations may be operated on a shorter term when and where there is a demonstrated need for monitoring. They are pollutant-oriented but not necessarily source-oriented.

Any comparison of data between stations must take these designations into account. Even when comparing contaminant levels in different cities for a specific type or class of station, some caution should be exercised, as the data represent the condition of the air in the vicinity of the individual monitoring stations, but may not necessarily represent community-wide air quality.

The contaminants monitored are: sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), suspended particulate (SP), and lead (Pb). In addition, the soiling or darkening potential of particulate in the atmosphere is measured

as the soiling index or coefficient of haze (COH). Measurements are made of dustfall and sulphation rates by the network, but are not analyzed in this report.

The great volume of air monitoring data generated by the nationwide network indicated the need for a single-value air quality index that could be used for socio-economic modelling, as an indicator of air quality, and as a basis for making rough comparisons of air quality in different urban areas. "Guidelines for an Annual Air Quality Index" were published by Environment Canada, on behalf of the Federal-Provincial Advisory Committee on Air Quality in 1980 (7). The index is based on the National Ambient Air Quality Objectives (8) and assumes that, at the defined objective levels, these individual air pollutants are equally important air quality indicators.

Since 1974, the NAPS annual summaries have not reported annual means of a contaminant for stations that do not meet a set of completeness criteria. For SO_2, NO_2, O_3, CO and COH, monthly or annual means are not calculated unless at least 50% of the hourly observations are available for the period concerned. Furthermore, the annual mean is not calculated unless monthly means are reported for at least two months in each quarter. For suspended particulate and lead, a monthly mean is not reported in the NAPS annual summaries unless a minimum of three samples is available for that month. The conditions for reporting the annual geometric mean are a minimum of 40 samples in the year with at least eight valid samples for each quarter. Beginning in 1985, the NAPS annual summary data for such pollutants as SO_2 are reported to an additional decimal place as recommended in the U.S. EPA's "Quality Assurance Handbook for Air Pollution Measurement Systems Vol. 1". According to the EPA, calculated values can be reported to one decimal place more than the observed value.

1.2 Air Monitoring Program

When established in January 1970, the NAPS network had 40 monitoring instruments in 14 cities, measuring SO_2, SP, lead and coh. In December 1985, the number of instruments had stabilized at about 400 in 55 cities across Canada and the list of contaminants monitored had expanded to include CO, NO_2 and O_3*. The growth of the network is illustrated in Figure 1 and the cities where monitoring instruments are located are shown in Figure 2. To emphasize the relationship of the allocation of monitoring stations with population, Figure 2 includes a population density map. The Class I Stations,

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* Another 52 instruments were used to measure dustfall and sulphation rate, but these particular indicators of air pollution are not dealt with in this report.

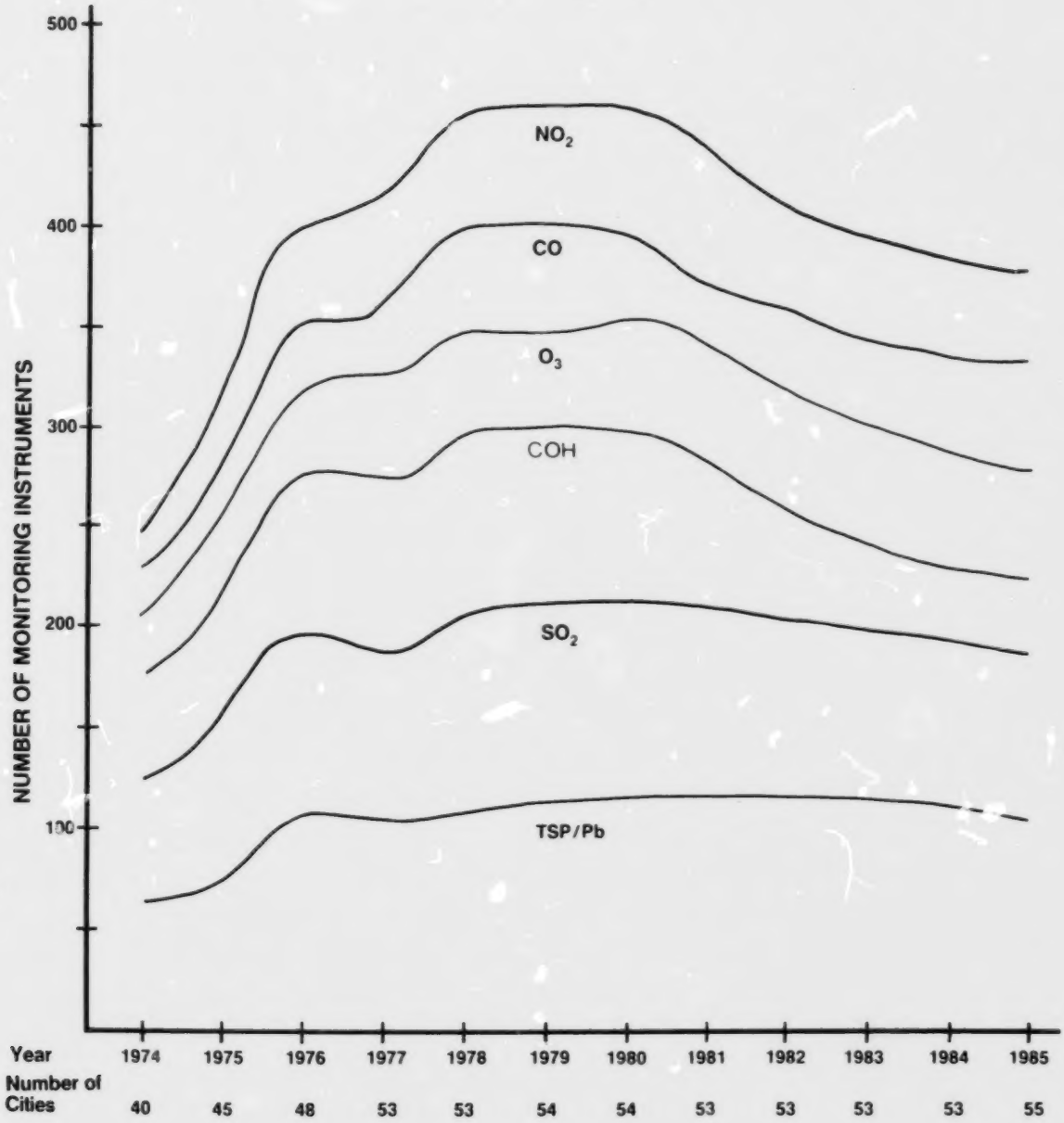
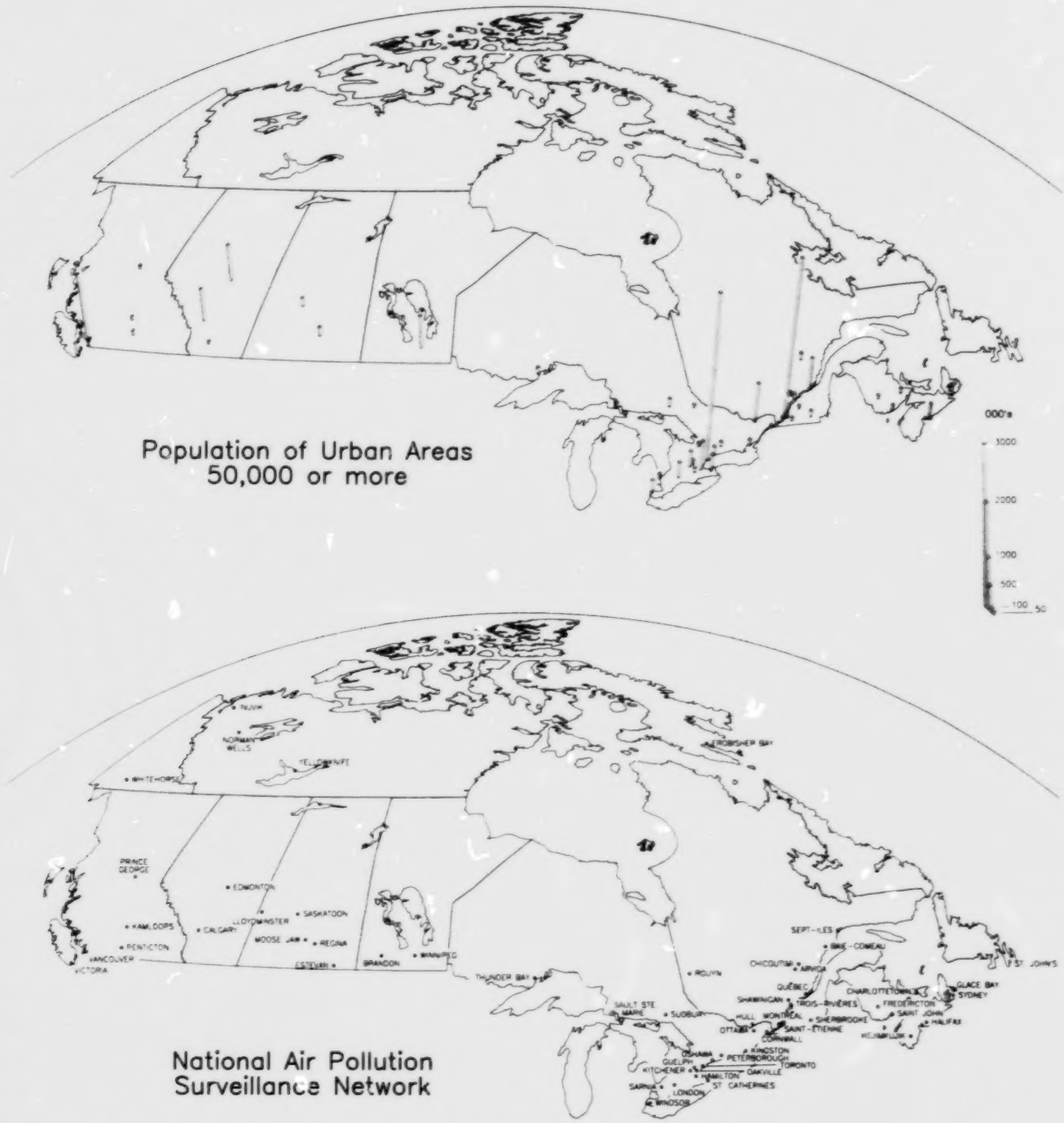


FIGURE 1 DISTRIBUTION OF STATIONS IN NAPS NETWORK 1974-1985



Source: 1981 Census of Canada.
Maps produced by the Geocartographics Subdivision and the Environmental Statistics Unit, Statistics Canada, 1987.

FIGURE 2 NATIONAL AIR POLLUTION SURVEILLANCE NETWORK (March, 1985)

their addresses and current status are listed in Table 1. When installation is completed, all air quality objective parameters and the coefficient of haze will be monitored at the Class I Stations. Most of these stations are located in downtown or major residential areas with potential for poor air quality, consistent with the site selection criteria.

1.3 National Ambient Air Quality Objectives (NAAQOs)

Air quality objectives have been established as a guide in developing programs to reduce the damaging effects of air pollution (8). These national objectives:

- assist in establishing priorities for reducing contaminant levels and the extent of pollution control needed;
- provide a uniform yardstick for assessing air quality in all parts of Canada; and
- indicate the need for and extent of monitoring programs.

The maximum acceptable level is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being. The maximum desirable level defines the long-term goal for air quality and provides a basis for an anti-degradation policy in unpolluted areas of the country. The maximum tolerable level denotes concentrations of air contaminants that require abatement without delay to avoid deterioration to an air quality that endangers the prevailing Canadian lifestyle or, ultimately, to an air quality that poses a substantial risk to public health. The desirable, acceptable and tolerable levels of the contaminants for the different averaging times in the present analysis are presented in Table 2.

1.4 Analytical Methods

1.4.1 Wilcoxon Matched Pairs Signed-ranks Test. The details of this procedure have been described in a previous report (2). It is a non-parametric test of high power and efficiency, provides an assessment of the magnitude of the differences between paired observations as well as the direction of the differences. In this study, the test has been used to overcome the difficulties resulting from a continual increase in the number of stations measuring each pollutant. It is used in order to determine whether there has been a statistically significant change in the annual averages of a pollutant at all monitoring stations across Canada for adjacent years.

The annual mean levels of a pollutant for two consecutive years are compared at each station. Paired data for two consecutive years are required and the magnitude of the increase or decrease is noted. Where a high proportion of stations experience an

TABLE 1 NATIONAL AIR POLLUTION SURVEILLANCE CLASS I STATIONS (status as of December 31, 1985)

City	Station	Location	Comments
Newfoundland:			
St. John's	10101C	Duckworth and Ordinance	no O_3 or NO_2 monitors
Nova Scotia:			
Halifax	30116C	Barrington and Duke	high-volume sampler located at site 30101C
New Brunswick:			
Saint John	40202C	Post Office	high-volume sampler located at site 40201C
Quebec:			
Montreal	50115C	Metcalfe and Maisonneuve	
	50116R	3161 Joseph, Verdun	
	50102R	Jardin Botanique	no soiling index monitor
	50109C	Duncan and Decarie	
	50112C	Boul. Laurentides	no soiling index monitor
	50110C	Parc Pilon, Montreal-Nord	
	50119R	1700 Bourassa, Longueil	no soiling index monitor
Hull	50203R	Gamelin and Joffre	no O_3 monitor
Quebec City	50307C	Parc Cartier Breboeuf	no soiling index monitor
Ontario:			
Ottawa	60101C	88 Slater Street	
	60104R	Rideau and Wurtemburg	no CO monitor
Windsor	60204C	471 University Avenue	
Toronto	60417C	26 Breadalbane Street	
	60412R	Bathurst and Wilson	no O_3 monitor
	60410R	Lawrence and Kennedy	
	60415R	Queensway W. and Hurontario	no soiling index monitor
	60402R	Don Mills, Science Centre	no soiling index monitor
	60413R	Elmcrest Road	
Hamilton	60501C	Barton and Sanford	
London	60901C	King and Rectory	
St. Catharines	61301C	North and Geneva	
Kitchener	61501C	Edna and Frederick	no soiling index monitor
Manitoba:			
Winnipeg	70119C	65 Ellen Street	
	70118R	Jefferson and Scotia	
Saskatchewan:			
Regina	80109C	1620 Albert Street	no soiling index monitor
Alberta:			
Edmonton	90130C	10255-104th Street	no SO_2 analyzer
	90122R	127 St. and 133rd Ave.	no SO_2 analyzer
Calgary	90227C	1611-4th Street S.W.	high-volume sampler located at site 90204C
	90222R	39 St. and 29th Ave. N.W.	no SO_2 analyzer
British Columbia:			
Vancouver	00112C	Robson and Hornby	high-volume sampler located at site 00109C
	00106R	2294 West 10th Avenue	
	00108I	250 West 70th Avenue	no SO_2 analyzer
	00110R	E. Hastings and Kensington	
	00111I	Rocky Pt. Park	
Victoria	00303C	1250 Quadra Street	

Note: as of December 1985, there were no COH monitors in the Eastern Region

TABLE 2 NATIONAL AMBIENT AIR QUALITY OBJECTIVES*

Pollutant	Averaging Time	Maximum Desirable Concentration	Maximum Acceptable Concentration	Maximum Tolerable Concentration
Sulphur dioxide	annual	11 ppb	23 ppb	-
	24-hour	57 ppb	115 ppb	306 ppb
	1-hour	172 ppb	344 ppb	-
Suspended Particulate	annual	60 $\mu g/m^3$	70 $\mu g/m^3$	-
	24-hour	-	120 $\mu g/m^3$	400 $\mu g/m^3$
Ozone	annual	-	15 ppb	-
	1-hour	50 ppb	82 ppb	153 ppb
Carbon Monoxide	8-hour	5 ppm	13 ppm	17 ppm
	1-hour	13 ppm	31 ppm	-
Nitrogen Dioxide	annual	32 ppb	53 ppb	-
	24-hour	-	106 ppb	160 ppb
	1-hour	-	213 ppb	532 ppb

* conditions of 25°C and 101.32 kPa are used as the basis for conversion from $\mu g/m^3$ to ppm or ppb

increase, the test will show whether the increase was statistically significant for those two years. A 95% confidence level is used. A pictorial summary of trends for each pollutant from 1974 to 1985 is displayed in Table 3.

The Wilcoxon test was also used to determine the equivalence of trends in air quality defined by Class I Stations compared to All Stations, using 1980-1981 data. As seen in previous reports (3,5) the short-term trends for the Class I Stations and All Stations were generally the same.

1.4.2 Tukey's Multiple Comparison Test. This trend analysis is simply a trend line composed of composite averages with their associated 95% confidence intervals. These intervals allow comparisons to be made between any two years in the analysis period. A significant change between years is indicated where the confidence intervals do not overlap. With Tukey's test, the confidence intervals are wide enough to compare the largest and smallest (yearly) averages in the analysis period with only a 5% chance of indicating a false significant change. This would not be the case for the Wilcoxon test, which measures a significant change between only two consecutive years.

The confidence intervals are calculated from an analysis of variance (ANOVA) of the concentration (mean or 98th percentile) of interest for each pollutant at each site

TABLE 3 STATISTICALLY SIGNIFICANT CHANGES IN AIR POLLUTION LEVELS, BASED ON ANNUAL MEANS FOR NAPS STATIONS ACROSS CANADA DURING 1974-1983

Contaminant	73-74	74-75	75-76	76-77	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85
Sulphur Dioxide	→	↓	→	→	↓	→	→	↓	→	↓	→	↓
Nitrogen Dioxide	N/A	N/A	N/A	N/A	→	↓	→	→	→	↓	↑	→
Carbon Monoxide	↓	↓	→	→	→	→	↓	→	↓	→	↓	→
Ozone	N/A	N/A	N/A	N/A	N/A	→	→	↓	↑	→	→	→
Suspended Particulate	→	↓	→	↓	→	↑	↑	↓	↓	↓	→	↓
Lead	↓	↓	↓	↓	↓	↓	↓	→	↓	↓	→	↓
Soiling Index	→	→	→	→	→	→	↓	↑	→	↓	→	→

↑ = Statistically Significant Increase

↓ = Statistically Significant Decrease

→ = Statistically No Significant Change

N/A = Not applicable; pollutant not monitored or results not considered reliable.

across all the years of the study. Since complete data was required to run the ANOVA, only stations that had valid data for 9 of 11 years (missing values estimated) were used in the analysis. This also explains any differences in annual mean levels that occur between this Tukey's test results and the box plot analysis that is based on all network stations. An example of the plotting convention is shown in Figure 3. A more complete explanation of the method can be found in a previous report (6).

Both the Wilcoxon and Tukey's Multiple Comparison tests take into account the uncertainty due to sampling variation as well as any changes in air contaminant levels that may be due to monitoring instrument sensitivity when determining the significance of a change. For theoretical reasons the Wilcoxon test is generally applied to pairs of adjacent years and is not suitable for comparing averages in the early and later years of an analysis period. The Wilcoxon test is more sensitive over the short-term but the Tukey Multiple Comparison test is a most effective way of presenting changes between all the years in an analysis period. Tukey's test results can provide comparisons at three levels to show:

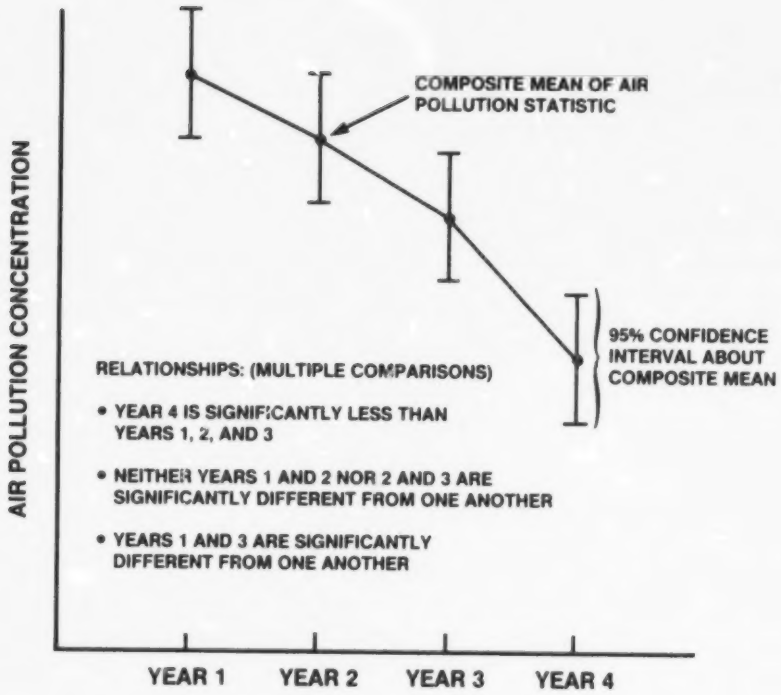

AIR POLLUTION CONCENTRATION
COMPOSITE MEAN OF AIR POLLUTION STATISTIC
95% CONFIDENCE INTERVAL ABOUT COMPOSITE MEAN
RELATIONSHIPS: (MULTIPLE COMPARISONS)
• YEAR 4 IS SIGNIFICANTLY LESS THAN YEARS 1, 2, AND 3
• NEITHER YEARS 1 AND 2 NOR 2 AND 3 ARE SIGNIFICANTLY DIFFERENT FROM ONE ANOTHER
• YEARS 1 AND 3 ARE SIGNIFICANTLY DIFFERENT FROM ONE ANOTHER
YEAR 1
YEAR 2
YEAR 3
YEAR 4

FIGURE 3 PLOTTING CONVENTION FOR TUKEY'S MULTIPLE COMPARISON TEST (10)

1. changes in concentration levels from year to year at Class I and All Stations;
2. significant change (0.05) where confidence intervals do not overlap at either Class I Stations or All Stations; and
3. relative concentration levels between Class I and All Stations.

1.4.3 Long-term Trend Analysis. Both the Wilcoxon and Tukey's tests are intended to be used for comparing the mean of one year to the mean of another. Neither test is suitable for determining the occurrence of a significant long-term trend over the analysis period. To test the significance of the long-term trend, a linear regression analysis was performed on the mean data (1974-1985) to determine whether the slope of the line was significantly greater or less than zero. The results show that the decreasing trend for the following pollutant indicators was significant at a 99% confidence level: the 98th percentile 1-hour CO concentration average annual change was 0.25 ppm; for particulate Pb (annual mean), 0.04 $\mu g/m^3$; NO_2, 0.6 ppb; SO_2, 0.11 ppb and suspended particulate,

2.3 $\mu g/m^3$. The results show that soiling index with an average annual change of 0.004 COH units decreased significantly at a 95% confidence level. Only the 98th percentile, 1-hour concentrations for ozone did not show a significant change from 1979 to 1985.

1.4.4 Box Plot Analysis. The box plot is a graphical technique used in exploratory data analysis to show the distribution of the annual means for All Stations calculated for the various contaminants. The plotting convention for the box plot is shown in Figure 4. For a given contaminant, the annual averages (or geometric means in the case of SP and lead) for all stations are grouped and ranked*. The percentiles indicate the percentage of stations with annual averages less than the specific levels identified.

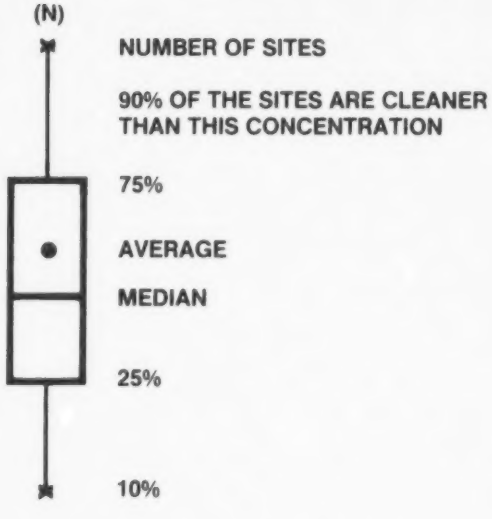


FIGURE 4 CONCENTRATION BOX PLOTTING LEVELS

In addition to the percentiles (10, 25, 50, 75 and 90), the annual average of all stations for the pollutant in a given year is also displayed. The annual trends at the

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* The change in the number of stations from year to year could possibly bias the annual average or percentiles calculated, distorting actual trends. To account for this, averages and percentiles were calculated for data from All Stations and Class I Stations. Values and corresponding trends for both were found to be similar. Consequently, because the total NAPS network gives a more representative national sample, data from all stations have continued to be used in the analysis.

favorable (10 to 25 percentiles), average (mean, median (50)), and unfavorable (75 and 90 percentiles) stations, therefore, can be analyzed separately (see the Appendix).

1.4.5 Analysis with Respect to NAAQOs. A third type of analysis used is based on the percentages of station data meeting or exceeding the NAAQOs in given years. This type of analysis is crude because it is insensitive to movement within particular air quality ranges. For example, all stations recording an annual mean for a particular contaminant may experience a decrease in the mean concentration from one year to the next. If none of the annual means drops below a particular objective; however, this type of analysis would indicate no change. Caution should be exercised when considering concentration levels higher than short-term air quality objectives (1-hour, 8-hour, 24-hour). A single occurrence will register a station as exceeding a particular level, be it desirable, acceptable, or tolerable, even though this may be one in several thousand readings taken at that station. In the following table the one-hour desirable level for carbon monoxide (13 ppm) has been exceeded at five Toronto stations; the acceptable level (31 ppm) has been exceeded at one of these stations.

If a comparison is made between station 60416C and 60401C, approximately 4.0% of the readings at station 60416C exceed the desirable level, whereas 0.4% of the readings at the other station exceed the same level. This type of analysis tends to identify potential air quality problems at specific sites. Consequently, it is used more in a supportive role to substantiate the first two types of analysis. For the same reason as in the box plot analysis, all stations have been used in calculating the percentage of stations with readings meeting or exceeding NAAQOs (Table 4).

TABLE 4 A COMPARISON OF STATION READINGS FOR CARBON MONOXIDE

Station	Location	1-hour Average CO, 1981		Total Readings
		>Desirable	>Acceptable	
60401C	67 College Street	14	0	3476
60402R	Don Mills, Science Cntr.	0	0	8105
60403I	Evans and Arnold	0	0	8387
60410R	Lawrence and Kennedy	1	0	8450
60412R	Bathurst and Wilson	1	0	8516
60413R	Elmcrest Road	0	0	7149
60414I	Sherbourne and Wilton St.	0	0	8299
60415R	Queensway W. and Hurontario	8	0	8607
60416C	381 Yonge Street	293	17	8481
60417C	26 Breadalbane	0	0	4297

2 SULPHUR DIOXIDE

Sulphur dioxide (SO_2) is a colourless gas and normally is not present in urban air at concentrations high enough for its odour to be detected. It is emitted into the atmosphere mainly from the primary production of copper and nickel, the combustion of sulphur-containing fuels, natural gas processing, iron ore processing and petroleum refining (14). Although air quality objectives for this contaminant have been set on the basis of known primary effects on health, vegetation and materials, secondary effects resulting from the role of sulphur dioxide in the formation of acid rain are now also of concern. It is important to note that for reasons given previously, the data are now analyzed to 1 ppb; the previous limit was 10 ppb. This change greatly affected the results of the analysis, and in fact the analysis of all the data from 1974 to 1985 was redone.

2.1 Annual Means

The composite average of sulphur dioxide annual means recorded by the NAPS network decreased from 13 ppb in 1974 to 6 ppb in 1985 (Figure 5 and the Appendix). Sulphur dioxide levels are showing signs of stabilizing; 1982 represents the first year where the percent change in the network annual mean is greater than that of the 90th percentile concentration. Results of the Wilcoxon test on the station annual mean data have determined that significant decreases occurred in 1974-1975, 1977-1978, 1980-1981, 1982-83 and 1985 (Table 3). The number of paired stations that registered changes in the annual arithmetic mean from one year to the next are found in Table 1 and the Appendix. In recent years, more than half of the paired stations show no change in annual mean concentrations.

Trends in composite annual mean values for All Stations and for Class I Stations with 95% confidence limits (derived using Tukey's Test) are shown in Figure 6. By inspection it is evident that the data for Class I Stations and All Stations convey the same general trend. In All Stations, however, there are many significant differences (where confidence intervals do not overlap) between years, such as 1985 and the years prior to 1982, whereas there is no significant change apparent in Class I Stations. It should be kept in mind that the number of stations in the analysis affect the magnitude of the confidence limits, and also that Class I Stations generally monitor commercial and residential centres that in turn are exposed to higher pollutant emissions.

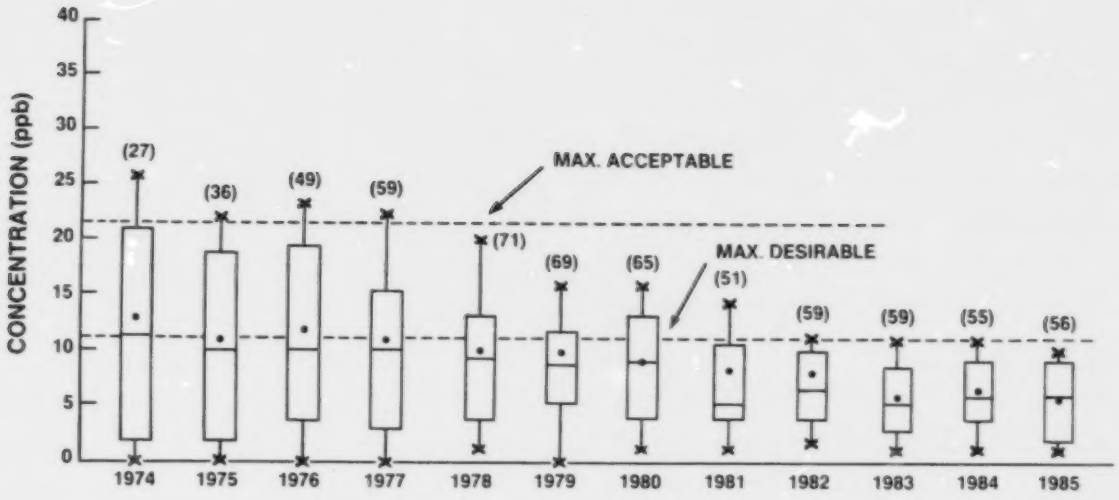


FIGURE 5 SULPHUR DIOXIDE - DISTRIBUTION OF STATION ANNUAL MEAN DATA (1974-1983)

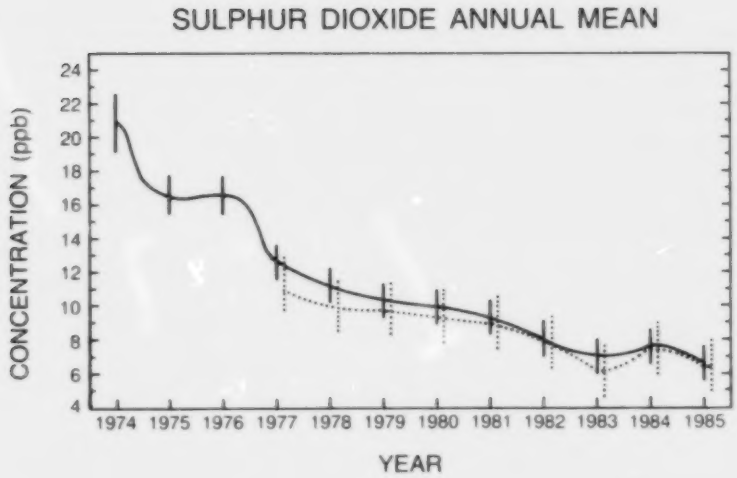


FIGURE 6 TRENDS IN SULPHUR DIOXIDE ANNUAL MEAN VALUES FOR ALL STATIONS (—) AND CLASS I STATIONS (...) (1974-1985) WITH 95% CONFIDENCE LIMITS

In recent years, more than 90% of the monitoring stations have reported annual mean values below the maximum desirable objective. Throughout the 1974-1985 year period there was a steady increase in the number of sites that met the maximum desirable objective. The percentage of stations with readings in various ranges with respect to the annual NAAQOs for 1974-1985 are found in the Appendix. Figure 7 shows the percentage of stations exceeding the objectives. The improvement achieved during this period is apparent in both instances.

Overall, the mean values from All Stations in Canada that meet NAPS siting criteria compare favorably with the objectives, although some stations have continued to register values in excess of the maximum acceptable level of 23 ppb. The stations with highest mean levels over the last nine years are listed in Table 5. From this table, the improvement at the worst sites is rather dramatic, particularly in Sudbury station (60606C) and Montreal station (50115C) where the annual mean levels that exceeded the acceptable objective have come down to below the desirable level.

2.2 Short-term Concentrations

2.2.1 24-hour Maximum Levels. During the 1977 to 1985 year period the maximum desirable level of the National Ambient Air Quality Objectives was exceeded by about 40% of the stations. The maximum acceptable level was exceeded in about 30% of the stations from a low of 21% in 1983 to a high of 44% in 1978 and 1979.

The maximum tolerable level was exceeded by about 1% of the network stations, with the exception in 1983 when three sites (4%) exceeded that level: the Quebec City station (50303I); the Baie Comeau station (51301R); and the Rouyn, Noranda station (50610C). These three stations are located near industrial as well as residential, commercial, and institutional heating sources. It is important to note that a single-day exceedance can be influenced by meteorological factors such as a temperature inversion, wind speed and direction, etc. Most stations register concentrations within the 24-hour acceptable range (i.e., 93% of the sites in 1980, and 95% in 1985). For 1984-85, all stations met the maximum tolerable objective along with an improvement in the percentage of stations meeting the maximum acceptable objective.

The plots of the composite 98th percentile concentrations show that there was a marked (95% confidence) improvement between early and later years at both the Class I Stations and in all the network stations. More significant decreases occurred between

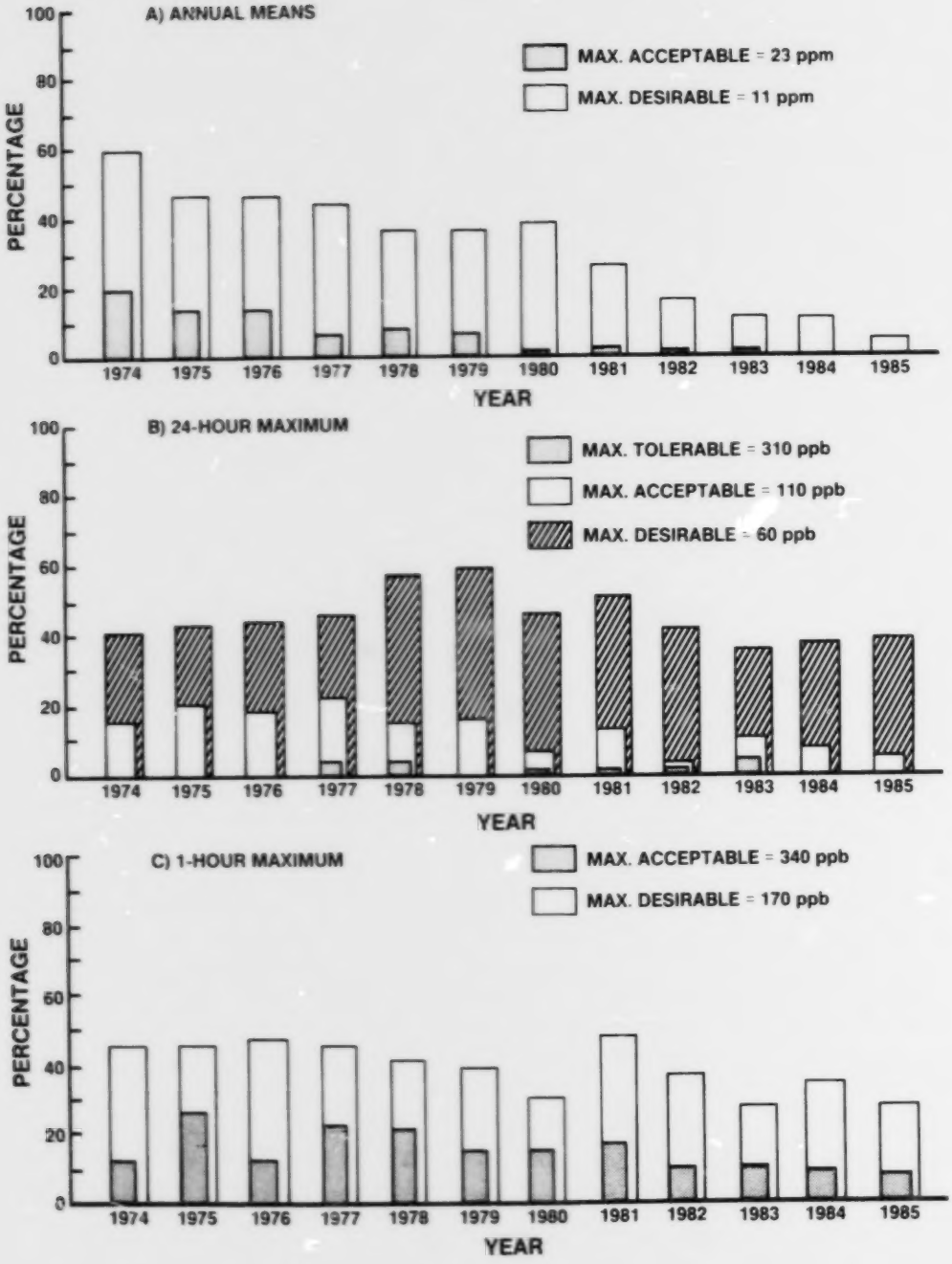


FIGURE 7 SULPHUR DIOXIDE - PERCENTAGE OF STATIONS REPORTING READINGS EXCEEDING NAAQOs (1974-1985)

TABLE 5 SULPHUR DIOXIDE - A SAMPLING OF THE HIGHEST ANNUAL MEANS BY CITY AND STATION OVER THE PAST NINE YEARS

City (Station)		Annual means (ppb)								
		1977	1978	1979	1980	1981	1982	1983	1984	1985
Halifax	(30116C)	9	11	14	19	15	10	11	11	10
Quebec City	(50303I)	43	20	25	19	---	---	34	21	12
Shawinigan	(51201I)	NM	26	---	15	17	12	---	12	10
Trois-Rivières	(50801R)	23	22	16	12	14	---	---	9	8
Arvida	(50901R)	---	20	15	20	20	15	16	17	9
Montreal	(50104C)	19	18	17	16	16	12	7	---	---
	(50115C)	NM	27	27	35	---	---	8	9	9
	(50103R)	21	28	19	---	23	20	14	10	18
Ottawa	(60101C)	13	15	13	11	10	11	5	9	9
Sudbury	(60606C)	23	13	11	13	10	8	8	10	10
	(60602R)	15	12	12	16	10	10	9	10	10
Sarnia	(61004R)	NM	17	17	13	14	12	10	9	11
Windsor	(60204C)	22	18	13	11	12	9	8	7	7
Cornwall	(61201R)	17	17	13	12	10	11	8	10	9
Hamilton	(60501)	23	16	17	13	10	14	14	15	9
Toronto	(60412R)	13	11	11	9	10	10	5	8	8

--- insufficient data for calculation of a valid mean
NM not measured

years because improvements at the extreme (90th percentile) values were proceeding at a faster rate.

2.2.2 1-hour Maximum Levels. When the 1-hour levels were analyzed with respect to the NAAQOs, no dramatic change was apparent from 1974 to 1985, only a general decrease in the percentage of stations registering readings in excess of the maximum desirable level (Figure 7). In 1974, 87% of the NAPS stations registered values that met the maximum acceptable level of 340 ppb, compared with 92% in 1985. Individual sites that registered 1-hour concentrations greater than the 1-hour maximum acceptable level in 1985 were: Rouyn, Trois-Rivières and Sudbury. Sudbury (660 ppb), and Rouyn (450 ppb) recorded the highest 1-hour concentrations in 1985. Industrial point sources contribute significantly to ambient sulphur dioxide levels at these sites.

An improvement that carries over from the last report is that fewer cities experienced episodes of SO_2 levels in excess of the maximum desirable. The plots of the 98th percentile concentration composite averages show many significant decreases (Figure 8). In the Class I station plot, a significant change (95% confidence) is indicated between 1985 and the years 1981, 1979 and 1977.

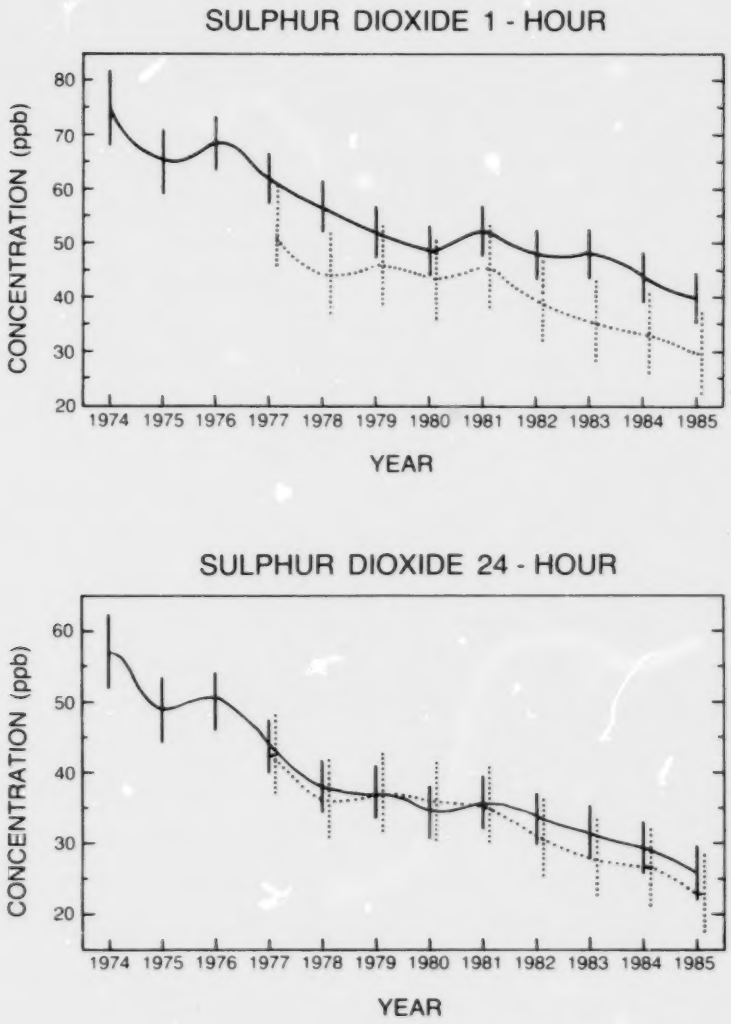


FIGURE 8 COMPOSITE AVERAGES OF THE 98th PERCENTILE CONCENTRATION 1974-1985 WITH 95% CONFIDENCE LIMITS FOR CLASS I (...) AND ALL STATIONS (—)

3 NITROGEN DIOXIDE

Gasoline-powered motor vehicles are historically the largest source of nitrogen dioxide emissions (14). Other important sources include diesel engines, industrial fuel combustion, power plants, and forest fires. Although the NAAQOs for this contaminant were established to prevent adverse human health effects and plant damage, the major role of nitrogen oxides in atmospheric photochemical reactions is also recognized, as is their significant contribution to acid rain.

As shown in Figure 1, nitrogen dioxide monitors were installed in the NAPS network in 1973. Data for the 1974-1977 period were discussed in a previous report (2). It has since been concluded that the data obtained prior to 1977 are unreliable due to instrumental and calibration difficulties. Only nitrogen dioxide data from 1977 to 1985, therefore, are considered in this report.

3.1 Annual Means

From 1977 to 1985, the composite average of the network nitrogen dioxide annual means decreased from 31 to 22 ppb (Appendix; Figure 9). Statistical tests (Wilcoxon) indicate that no significant change in the national annual mean value occurred for the 1979-1982 period (Table 3) 1983 (decrease) and 1984 (increase). The number of paired stations indicating changes in annual means are listed in the Appendix. The composite averages of annual mean values with their associated 95% confidence limits (derived from Tukey's test) for All Stations and for Class I Stations are presented in Figure 10 for the 1977-1985 period. Both sets of stations show similar trends; however, measured concentrations at Class I Stations tend to be higher because they are located in the core of the city.

In both cases, 1985 annual mean levels are significantly lower than 1978, indicating a real improvement in nitrogen dioxide levels. In the past two years, the mean levels have increased, but no significant changes have occurred since 1979 (Figure 10).

The composite averages of station annual means for nitrogen dioxide remained within the desirable level between 1977 and 1985. During this period, the annual mean levels continued to decrease, albeit by small increments (Appendix). As shown in Figure 11, the number of stations meeting the maximum desirable level increased from 59% in 1977 to 90% in 1985. No individual station has registered readings in excess of the maximum acceptable level since 1977. The highest annual mean for nitrogen dioxide in 1985 occurred at a commercial (city centre) site in Calgary (36 ppb).

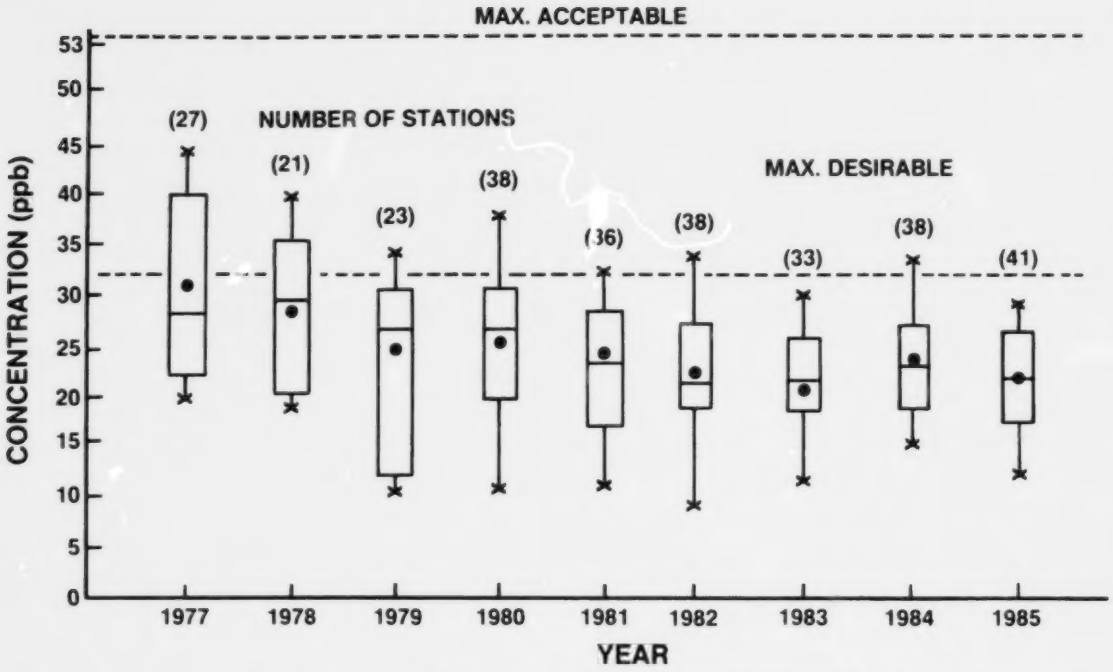


FIGURE 9 NITROGEN DIOXIDE - DISTRIBUTION OF STATION ANNUAL MEAN DATA (1977-1985)

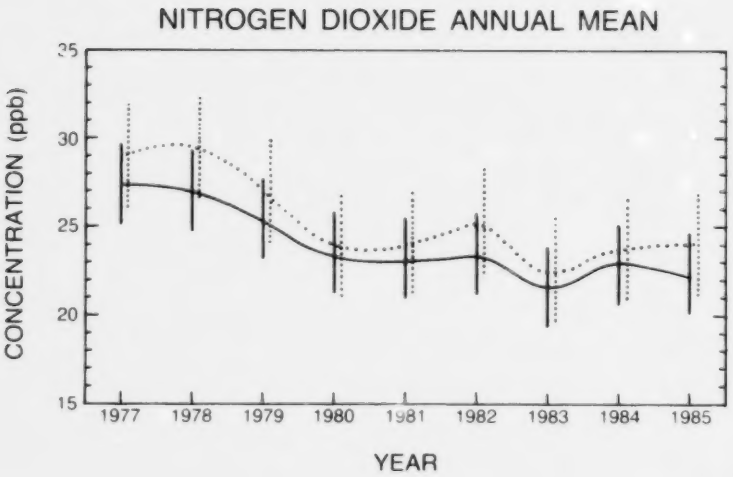


FIGURE 10 TRENDS IN NITROGEN DIOXIDE ANNUAL MEAN VALUES FOR ALL STATIONS (—) AND CLASS I (...) STATIONS (1977-1985) WITH 95% CONFIDENCE LIMITS

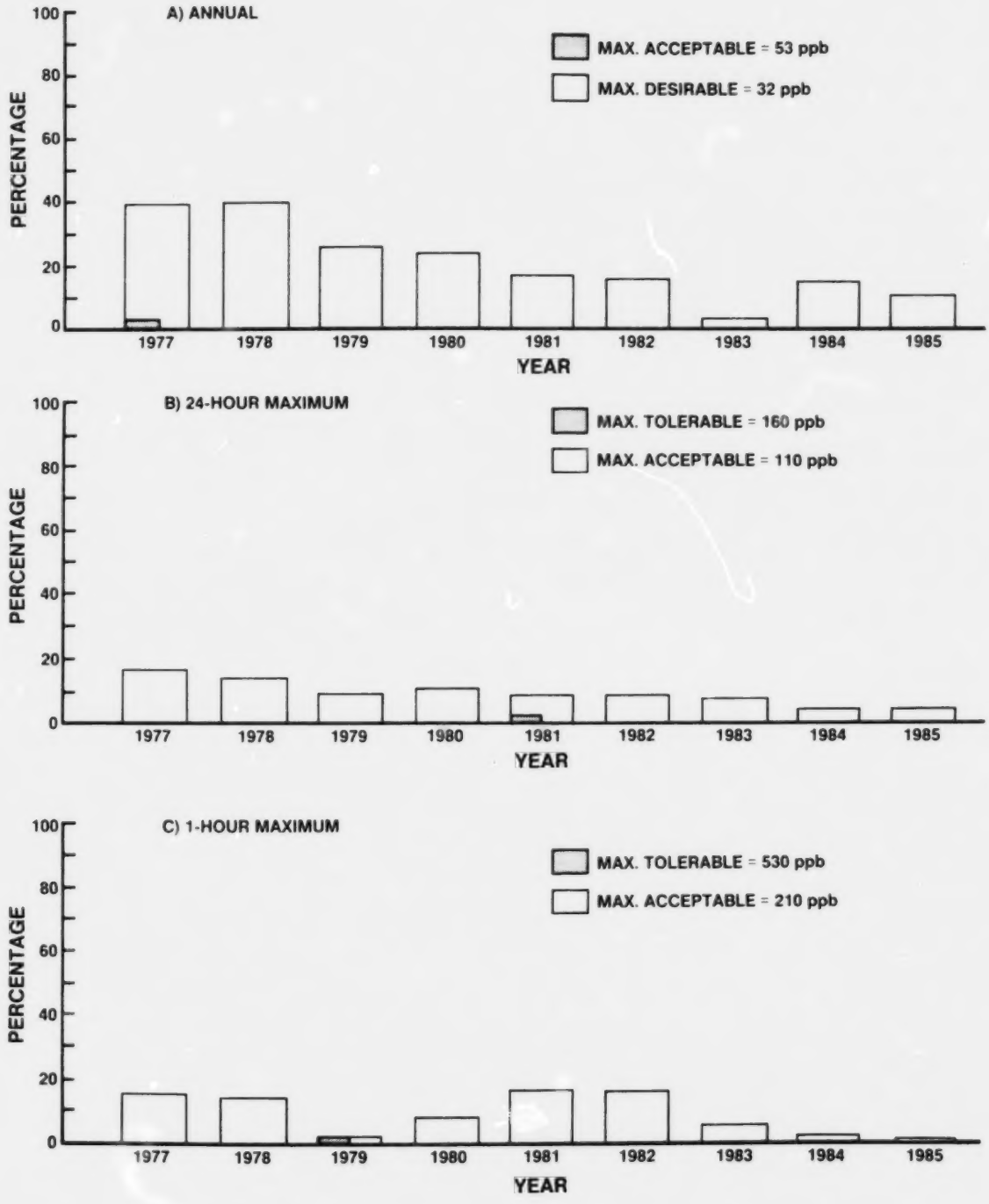


FIGURE 11 NITROGEN DIOXIDE - PERCENTAGE OF STATIONS REPORTING READINGS EXCEEDING NAAQOs (1977-1985)

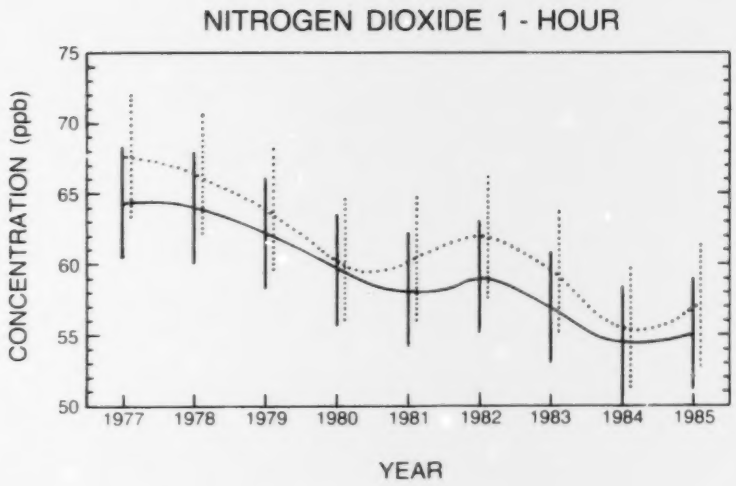
3.2 Short-term Concentrations

3.2.1 24-hour Maximum Levels. The long-term improvement shown in annual mean nitrogen dioxide levels was reflected by a trend to fewer stations exceeding the 24-hour maximum acceptable level of 110 ppb (Figure 11). In 1977, 84% of the stations met the maximum acceptable 24-hour level of 110 ppb, compared with 96% in 1985. All of the stations met the maximum tolerable 24-hour level of 160 ppb during the last four years. From Figure 12, the general trend for Class I Stations and All Stations is equivalent; however, All Stations show a significant (95% confidence) decrease between 1985 and the years prior to 1980.

3.2.2 1-hour Maximum Levels. The percentage of stations that reported readings meeting the maximum acceptable 1-hour level of 210 ppb was higher in 1985 than in previous years; this objective level was met at virtually all of the sites (Figure 11). No stations, however, reported readings in excess of the maximum tolerable 1-hour level (530 ppb) since 1979, and none did so prior to 1979.

The improvement at the 98th percentile composite average of the 1-hour concentrations is illustrated in Figure 12. There was a significant (95% confidence) decrease between 1985 and the years prior to 1980 in the All Stations plot. The Class I Stations plot does not show the same number of significant differences; however, it is important to show that the general trend is the same.

Although there was an increase in the annual mean in 1984, this increase is not reflected in the 1-hour or the 24-hour plots (98th percentile concentration).



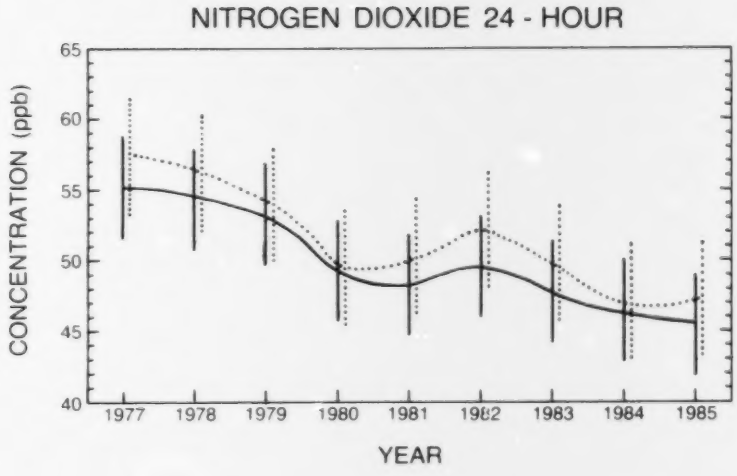


FIGURE 12 COMPOSITE AVERAGES OF THE 98th PERCENTILE CONCENTRATION (1977-1985) WITH 95% CONFIDENCE LIMITS FOR CLASS I (...) AND ALL STATIONS (—)

4 CARBON MONOXIDE

Carbon monoxide (CO) is produced by the incomplete combustion of any organic fuel. The primary source of carbon monoxide emissions is the gasoline-powered motor vehicle. Other important sources are stationary fuel combustion, forest fires, agricultural and slash burning, the non-highway use of gasoline, and petroleum refining processes (14). Ambient air quality objectives for this pollutant were established to prevent adverse health effects in humans.

4.1 Annual Means

The composite average of CO annual means for the NAPS network decreased from 2.4 ppm in 1974 to 1.7 ppm in 1976, and remained relatively constant from 1976 to 1981 followed by decreases in the 1982-85 period to a level of 1.0 ppm (Figure 13). The higher concentrations (90th percentile) recorded at stations in more polluted areas, have decreased from a high of 3.2 ppm in 1979 to 1.8 ppm in the past two years.

When a Wilcoxon test was applied to determine whether the change between any two consecutive years was significant, carbon monoxide levels were found to have decreased in 1973-1974, 1974-1975, 1979-1980, 1981-82 and 1983-1984 (Table 3). The number of paired stations indicating changes in annual mean data for carbon monoxide are summarized in the Appendix.

Trends in the composite average of carbon monoxide annual means for All Stations and Class I Stations with 95% confidence (Tukey's test) limits are shown in Figure 14. As with other pollutants, the trend (Class I and All Stations) is similar and it can be concluded that Class I Stations by themselves would provide a representative national sample of carbon monoxide levels. However, due to the number of stations involved in the analysis of variance (ANOVA), "All Stations" generally, is a better indicator of year to year change. In this case, both Class I Stations and All Stations show the same long-term trend, with All Stations being significantly lower in 1985 than in 1981 (at 95% confidence) and the years previous. These decreases have been brought about by improvements at sites that commonly registered the highest values.

The highest reported station annual means in 1985, 3.7 ppm and 2.5 ppm, were recorded at commercial sites in Toronto and Vancouver, these levels as well as the number of high stations have come down markedly in the 1980s. Since both stations are

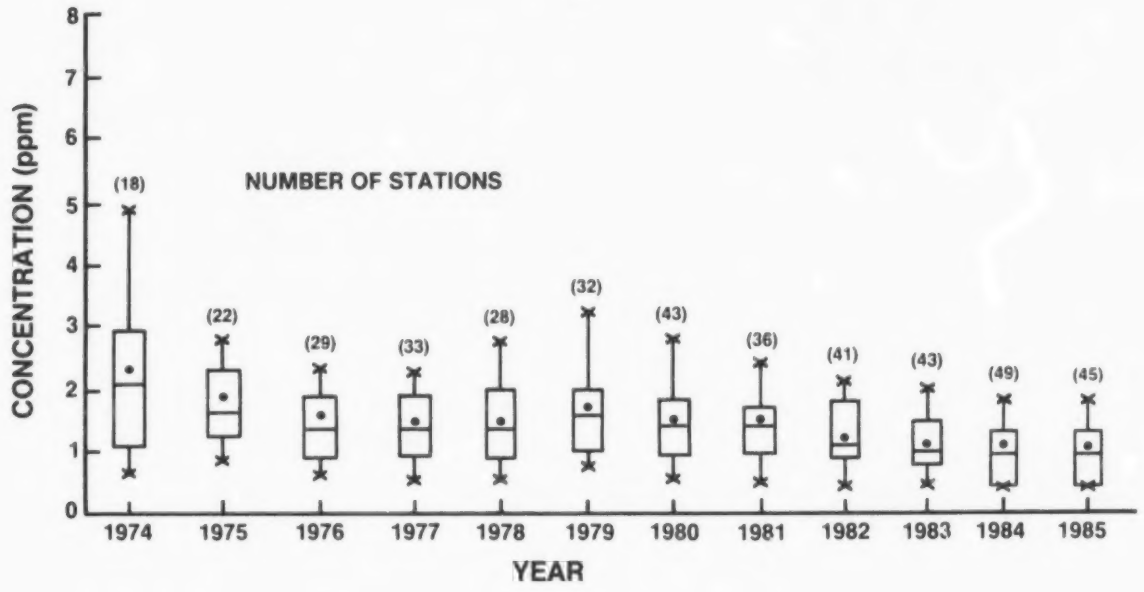


FIGURE 13 CARBON MONOXIDE - DISTRIBUTION OF STATION ANNUAL MEAN DATA (1974-1985)

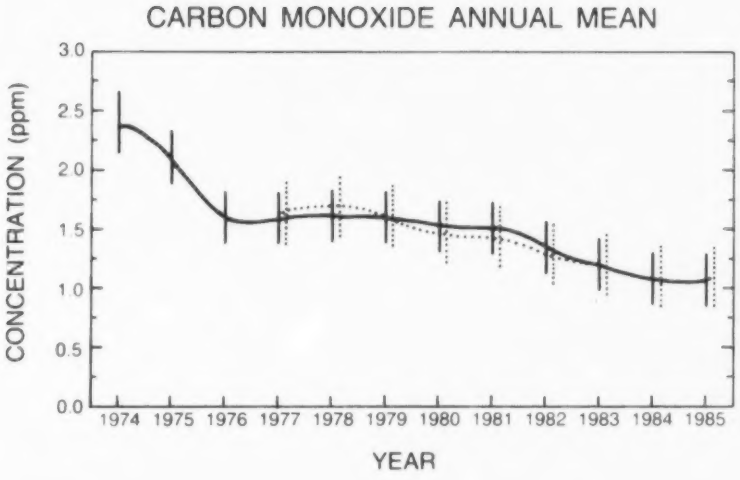


FIGURE 14 TRENDS IN CARBON MONOXIDE ANNUAL MEAN VALUES FOR ALL STATIONS (—) AND CLASS I STATIONS (...) (1974-1985) WITH 95% CONFIDENCE LIMITS

downtown sites located near major traffic arteries, this decrease reflects a general lowering of the per car emission rate (17) over the review period. From a "Summary Report, Canadian Energy Supply and Demand 1983 to 2005" there is evidence that in the 1979 to 1985 period the demand for heating fuel and gasoline was declining (15). These factors would point to a reduction in the ambient levels of carbon monoxide at sites that traditionally record the highest annual mean concentrations.

4.2 Short-term Concentrations

4.2.1 8-hour Maximum Levels. The percentage of stations meeting the 8-hour acceptable objective have continued to increase, from 71% in 1974 to 94% in 1985 (Figure 15). The number of stations reporting readings in excess of the maximum acceptable and maximum tolerable levels account for the fluctuations in the period from 1976 to 1981. The site reporting a concentration in excess of 17 ppm (maximum tolerable level) in 1985 was Toronto station (60416C) at 22 ppm.

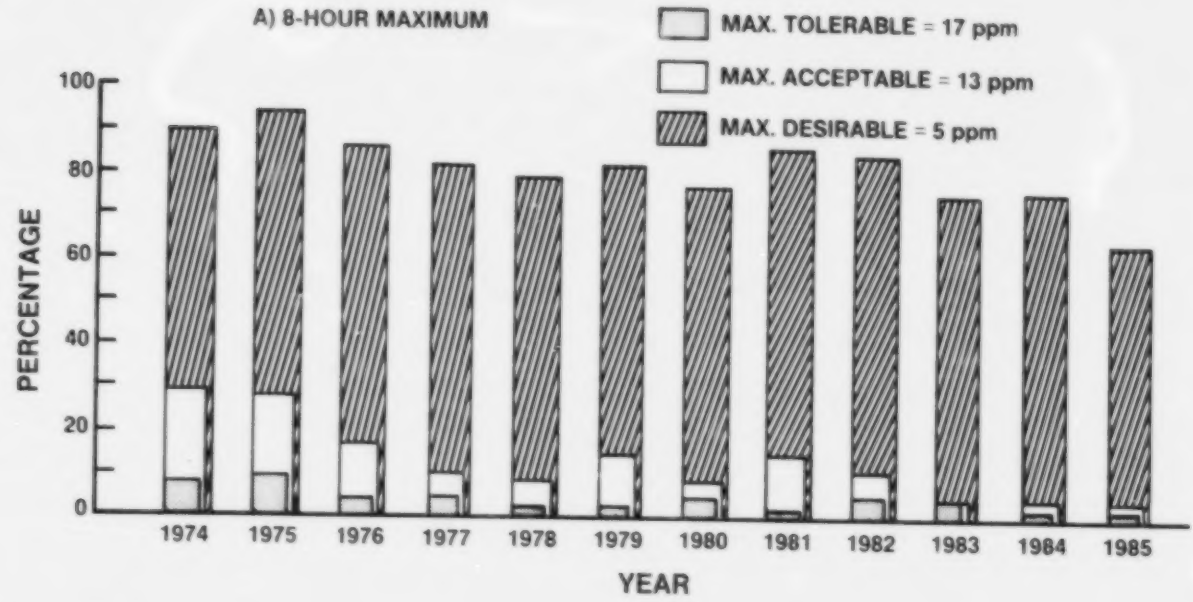
The percentage of stations reporting average 8-hour readings in various ranges with respect to 8-hour NAAQOs from 1974 to 1985 are summarized in the Appendix.

Figure 16 shows the trend in the composite average of the 98th percentile (8-hour) concentrations at Class I Stations and All Stations. In this case All Stations show more significant changes between years with 1985 showing an improvement over 1981 and 1979 as well as the years prior to 1978.

4.2.2 1-hour Maximum Values. The number of stations reporting readings higher than the 1-hour maximum desirable carbon monoxide level of 13 ppm have been decreasing over the years, with a rather sharp decrease occurring in 1980 (Figure 15). The number of stations with readings exceeding the maximum acceptable level varied from 2% to 8%, without any apparent trend since 1974. Readings in excess of the maximum acceptable 1-hour and 8-hour levels occurred at only one Toronto site in 1985 (Station 60416C). No other sites exceeded the maximum acceptable 1-hour level.

The percentage distribution of stations in various ranges with respect to the 1-hour NAAQOs from 1974 to 1985 is shown the Appendix.

Figure 16 shows the trend in the composite average of the 1-hour 98th percentile concentrations. Again the All Stations plot shows more significant differences with 1985 levels being significantly better than 1981 and the years prior to 1980.



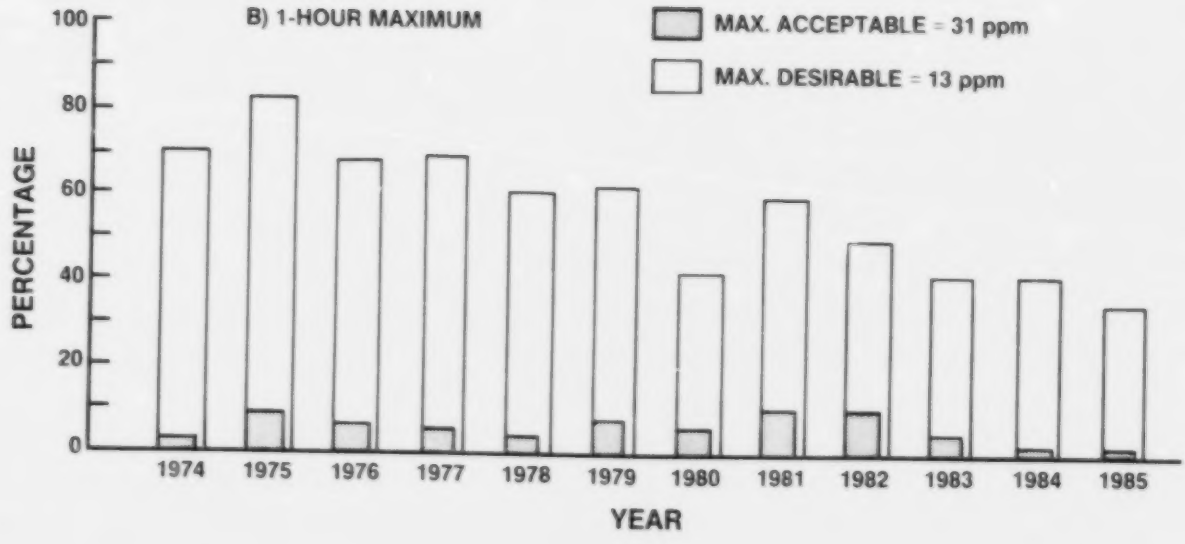
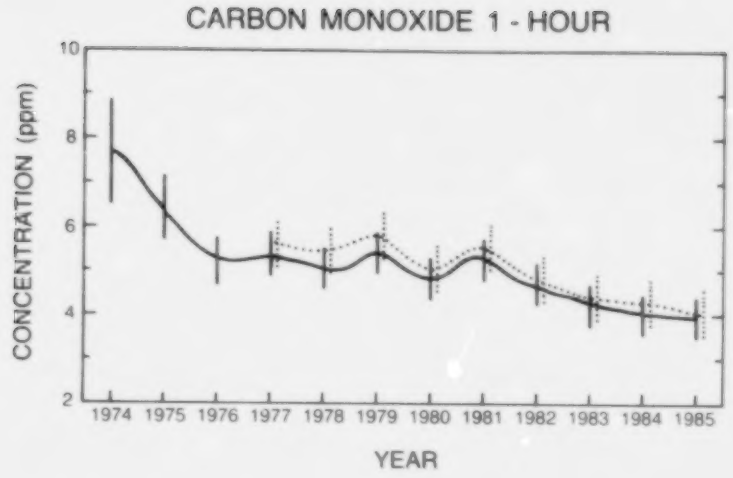


FIGURE 15 CARBON MONOXIDE - PERCENTAGE OF STATIONS REPORTING READINGS EXCEEDING NAAQO'S (1974-1985)



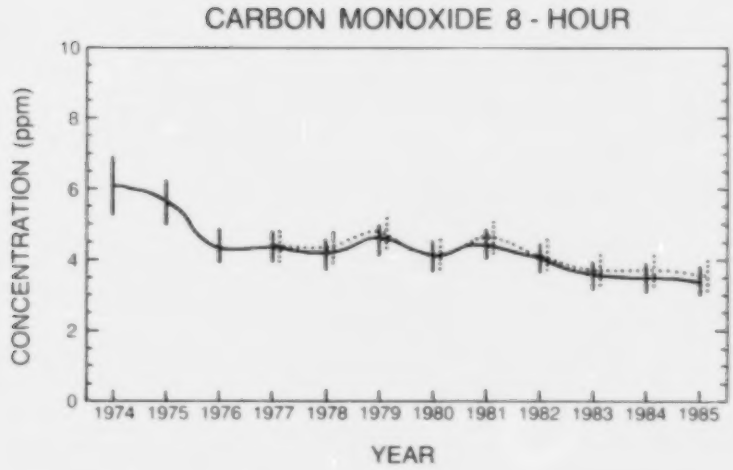


FIGURE 16 COMPOSITE AVERAGES OF THE 98th PERCENTILE CONCENTRATIONS WITH 95% CONFIDENCE LIMITS FOR CLASS I (...) AND ALL STATIONS (—) (1974-1985)

5 OZONE

Ozone is the principal species of several oxidizing gases known collectively as total oxidants. Atmospheric ozone concentrations increase as a result of photochemical reactions which occur under conditions of strong sunlight and high concentrations of hydrocarbons and nitrogen oxides. These precursors to atmospheric ozone formation are emitted primarily from gasoline-powered motor vehicles, residential, commercial and industrial fuel combustion, and diesel engines. Ambient air quality objectives for ozone have been set on the basis of known adverse effects on vegetation, materials and human health.

Ozone monitors were first installed in the NAPS network in 1973 (Figure 1). Data for the 1973-1974 period were presented in an earlier report (1,2). With the subsequent implementation of a common calibration procedure for ozone monitors across the NAPS network, it was found that the data was unreliable. In order to avoid assessments based on unreliable data, it was decided to delay the interpretation of ozone data until all questions of methodology were resolved. It is now believed that the ozone measurements made throughout the network after 1978 are reliable and consistent.

5.1 Annual Means

Annual ozone concentrations beginning in 1979 are presented in Figure 17. The overall average of ozone annual means for the NAPS network in 1985 was 17 ppb. Values for individual stations ranged from 5 ppb in Vancouver (00112C) to 27 ppb in Regina (80109C). Most station annual means in southern Ontario were in the 10 ppb to 26 ppb range. The characteristic seasonal pattern of highest levels during the summer months was generally observed. Trends in average 98th percentile ozone concentrations at all stations and Class I Stations are shown in Figure 18. The number of stations indicating changes in annual mean ozone concentrations between 1979 and 1985 is shown in the Appendix.

The maximum acceptable annual mean level for ozone is 15 ppb. As shown in the Appendix, less than half of the monitoring sites met this objective. The sites exceeding this level were quite evenly distributed across the network, but all southern Ontario sites outside of the Toronto-Hamilton urban area reported readings higher than the maximum acceptable level. The reduction of ozone levels by nitrogen oxide scavenging in urban and industrial areas has been a generally accepted fact for many years.

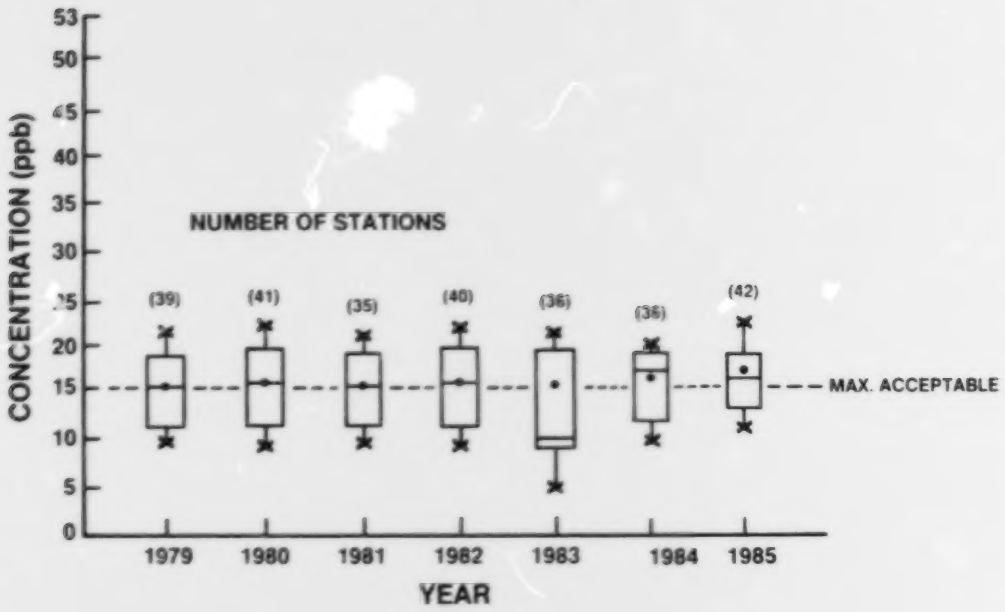
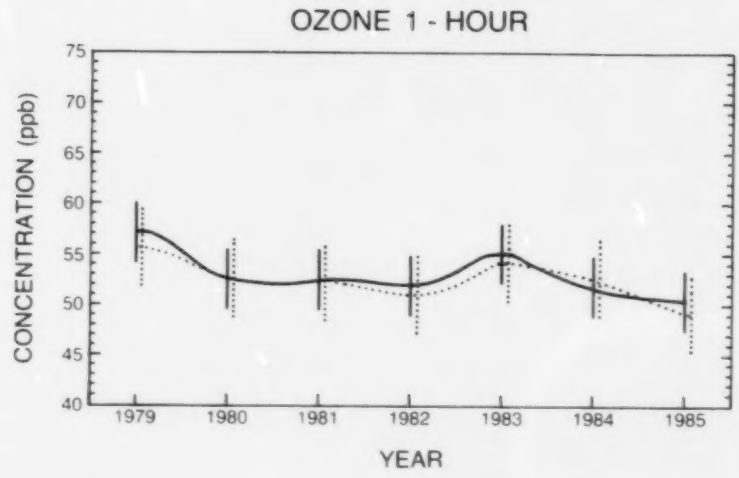


FIGURE 17 OZONE - DISTRIBUTION OF ANNUAL MEAN DATA (1979-1985)

5.1.1 **1-hour Maximum Levels.** Maximum desirable, acceptable and tolerable 1-hour ozone objectives can be found in Table 2. The percentage of stations showing 1-hour values in the ranges defined by these objectives are summarized in the Appendix. About 4% of the sites reported values in excess of the maximum tolerable level of 150 ppb. These were, in most instances, single occurrences.

According to an EPA report on air quality indicators (19) a better indicator of ozone trends is the analysis of 1-hour, 98th percentile concentrations (peak statistics). The reason for this is that ozone is a seasonal pollutant and this character is lost in the annual mean, therefore, no meaningful trend can be determined. In Figure 18 greater variation in the 1-hour data occurs, with 1983 showing a pronounced increase over previous levels. According to the U.S. air quality trends report (16), 1983 was an unusually high ozone year, particularly in the northern states. This same trend is better illustrated by the 1-hour, 98th percentile concentration plot. However, due to the variability in the data and the rather low number of stations in the ozone network the only significant change over the long-term (Tukey's test) was found between 1979 and 1985. Significant (95% confidence) changes are indicated using the Wilcoxon test for 1981 and 1982 (Table 3).



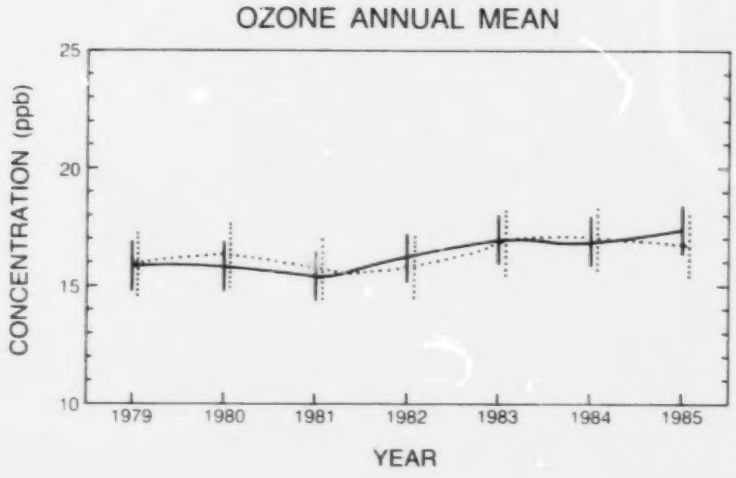


FIGURE 18 TRENDS IN OZONE ANNUAL MEAN AND 98th PERCENTILE 1-h CONCENTRATIONS FOR ALL STATIONS (—) AND CLASS I STATIONS (...) WITH 95% CONFIDENCE LIMITS (1979-1985)

6 SUSPENDED PARTICULATE

Total suspended particulate (TSP) is a general term applied to a wide variety of solid or liquid particles of a size and configuration such that they tend to remain airborne (aerosol). The portion of TSP known as inhalable particulate can be drawn deep into the respiratory tract. Particulate matter is the most commonly perceived form of air pollution, often manifested itself by impairment of visibility, soiling of materials and irritation of the respiratory tract. The particle size and chemical composition of particulate emissions from the most significant sources in Canada have been determined (11). Ambient air quality objectives have been established with the goal of minimizing these undesirable effects.

Iron ore mining and beneficiation, mining and rock quarrying, sulphate (kraft) pulping, power plants, slash burning, and cement manufacturing are all important sources of suspended particulate matter. Forest fires, wind erosion and fugitive dust emissions contribute to the natural background levels (14).

In Table 2, there are suspended particulate National Ambient Air Quality Objectives listed for both the annual mean and the 24-hour average concentrations. However, given the NAPS schedule of sampling once every six days; only the annual mean is used as a trend statistic (19).

Annual Geometric Means. The composite averages of the station annual geometric means have decreased approximately 45% between 1974 and 1985, and mean values appear to be levelling off in the 43 $\mu g/m^3$ range (Figure 19 and the Appendix). The decrease in average levels can be attributed to improved conditions at the more polluted sites. When statistical analysis (Wilcoxon) was applied to determine whether the changes in consecutive years were significant, TSP levels were found to have decreased significantly in 1974-75, 1976-77, 1980-81, 1981-82, 1982-83 and 1984-85 (Appendix). The significant increases in 1978-79 and 1979-80 appear to have been (general increases at all sites) due to unusually mild winters. The number of paired stations indicating changes in annual means from 1974 to 1985 are summarized in the Appendix.

Long-term changes (Tukey's test) in the composite annual mean values for All Stations and Class I Stations for 1974-1985 are shown in Figure 20. While the general trends indicated by the two sets of stations are similar, the absolute values shown by the Class I Stations are higher. In more recent years, the agreement is such that Class I Stations alone can provide a representative sample of TSP levels.

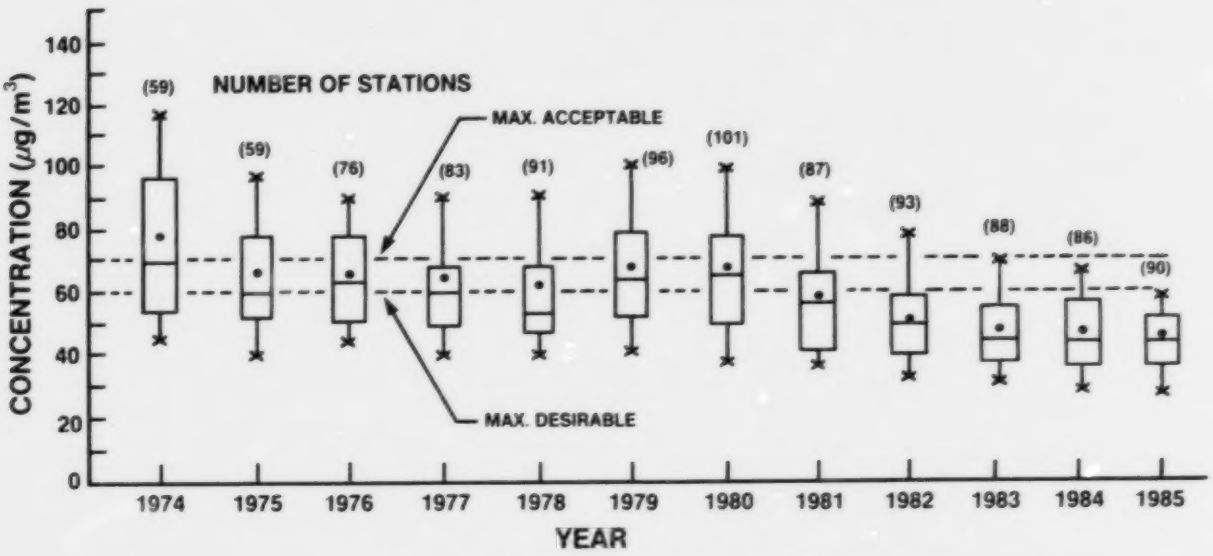


FIGURE 19 SUSPENDED PARTICULATE - DISTRIBUTION OF STATION ANNUAL MEAN DATA (1974-1985)

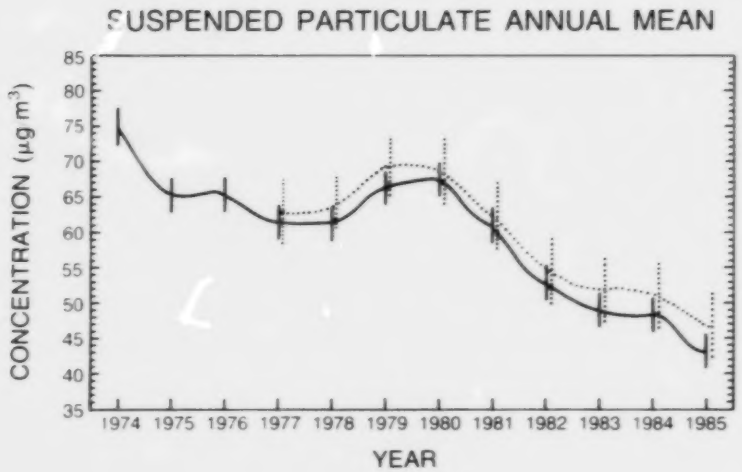


FIGURE 20 TRENDS IN SUSPENDED PARTICULATE ANNUAL MEAN VALUES FOR ALL STATIONS (—) AND CLASS I STATIONS (...) (1974-1985) WITH 95% CONFIDENCE LIMITS

As a result of the greater number of stations used to calculate the confidence intervals (Tukey's test) for the years 1974 to 1985 "All Stations" provide a better indicator of long-term change. By inspection we can see that 1985 was a significant (95% confidence) improvement over the preceding years, while 1982, was in turn a significant improvement of over all other previous years. From Figure 19, it is evident that the network annual means have been below the Annual Maximum Acceptable level (NAAQOs) since 1975.

Improvements in TSP over the past five years have occurred at all percentile levels, such that the 75th percentile concentration in 1985 is below the maximum desirable objective level of 60 $\mu g/m^3$ (Figure 19). To underscore the dramatic improvements in TSP levels in recent years the network annual mean values from 1975 to 1980 were consistently above 60 $\mu g/m^3$ and are now (1985) in the 43 $\mu g/m^3$ range.

The percentage distribution of stations with annual mean concentrations exceeding the annual objectives are shown graphically in Figure 21. Another indicator of the improvement in particulate levels is the increasing percentage of station means meeting the desirable and acceptable levels in 1984-85. Approximately 2% of the stations measuring TSP exceeded the maximum acceptable level of 70 $\mu g/m^3$ in 1985, compared with 50% in 1974. Similarly, the percentage of stations with annual means meeting the maximum desirable objective of 60 $\mu g/m^3$ increased from 30% in 1974 to 80% and 90% in 1984 and 1985, respectively. The percentage of stations reporting annual means in the various ranges defined by the NAAQOs are summarized in the Appendix.

Stations reporting the highest annual means in 1985 were: Toronto station (60414I), 87 $\mu g/m^3$; Montreal station (50109C), 100 $\mu g/m^3$; Windsor station (60212I), 73 $\mu g/m^3$. Other cities with stations reporting annual mean values in excess of maximum desirable level (60 $\mu g/m^3$) were: Yellowknife, Vancouver, and Hamilton. Elevated total suspended particulate levels can be associated with sites that are near a major traffic artery, heavy industry or near a construction site.

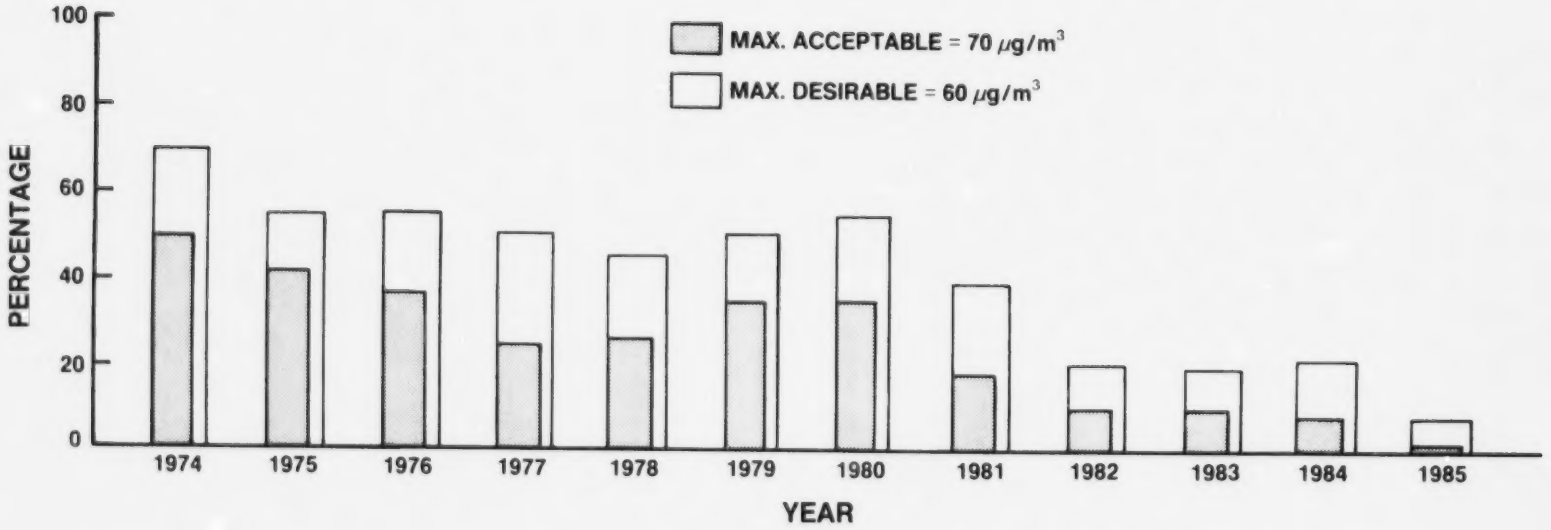


FIGURE 21 SUSPENDED PARTICULATE - PERCENTAGE OF STATIONS REPORTING READINGS EXCEEDING ANNUAL NAAQOs (1974-1985)

7 LEAD

Lead in the ambient air has long been recognized as a potential threat to human health. Gasoline-powered motor vehicles account for more than 85% of total airborne lead emissions in Canada. Other sources include the primary production of copper and nickel, and the operations involved in lead mining, milling, smelting and refining (13).

Lead is present in ambient air as a component of suspended particulate and is determined by analyzing the filter samples collected for suspended particulate matter.

Annual Geometric Means. The composite average of the network annual mean lead concentrations decreased by about 74% between 1974 and 1985 (Appendix; Figure 22). Stations in more polluted areas have shown consistent improvement as indicated by the decrease in the 90th percentile concentration. Statistical tests (Wilcoxon) to determine the significance of the change between any two consecutive years show that annual lead levels decreased significantly in all years except 1981 and 1984, when no trend was indicated (Table 3). The number of stations indicating changes in paired annual geometric mean data are listed in the Appendix.

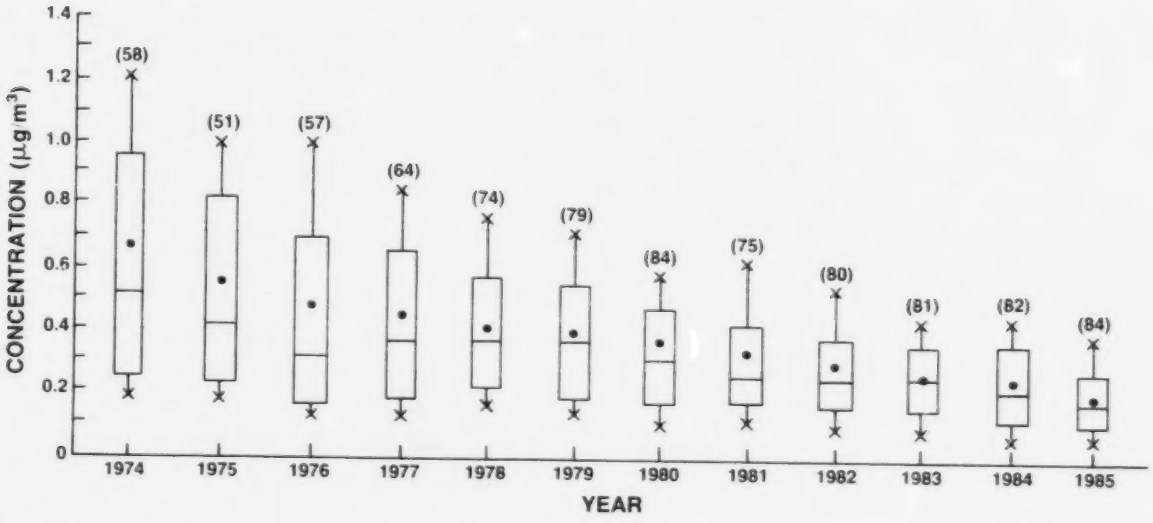


FIGURE 22 LEAD - DISTRIBUTION OF STATION ANNUAL MEAN DATA (1974-1985)

Average annual mean lead concentrations measured at selected stations (valid data for 9 of 11 years) in the NAPS network are shown in Figure 23. Class I Stations show higher levels than do All Stations, which is consistent with the fact that Class I Stations tend to be located in downtown (central urban) areas where lead levels are expected to be higher. The data indicate a convergence of the average levels measured by the two sets of stations, but the Class I average continued to be somewhat higher than the overall average from 1974 to 1979. In Figure 23 the long-term change using Tukey's test is presented for All Stations (network) and there appears to be a significant decrease every few years rather than every year as with the Wilcoxon test. The most recent trend results indicate that 1985 is significantly lower than 1981 and the preceding years. As more and more automobiles use unleaded fuel the rate of this decreasing trend should become more pronounced as we approach background levels.

Historically the highest lead concentrations have occurred in cities. Station parameters, concentration levels, and traffic density for the highest lead sites for 1983 and 1985 are provided in Table 6.

Although some of these stations may be near an industrial source such as a smelter or a metal remelting operation, one common feature is their proximity to high traffic density or, more specifically, to the major source of urban suspended particulate lead emissions--the gasoline-powered motor vehicle.

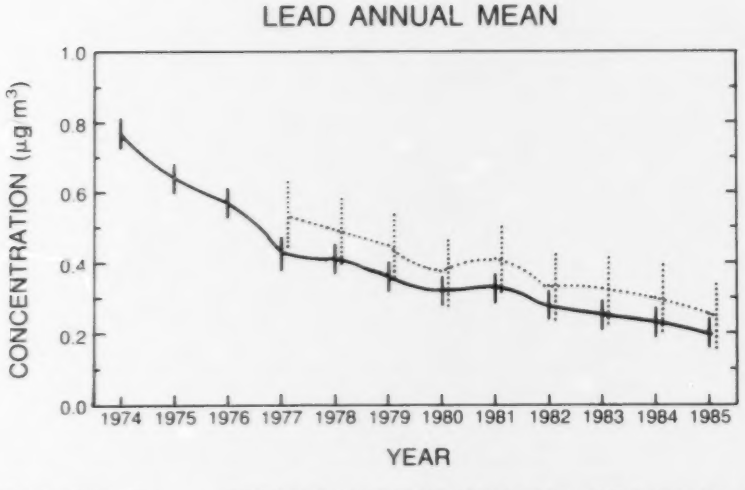


FIGURE 23 TRENDS IN LEAD ANNUAL MEAN VALUES FOR ALL STATIONS (—) AND CLASS I STATIONS (...) (1974-1985) WITH 95% CONFIDENCE LIMITS

TABLE 6 MONITORING SITES* WITH HIGHEST MEASURED LEAD CONCENTRATIONS IN 1983 AND 1985

Station No.	City	Address	Annual Geometric Mean ($\mu g/m^3$) (1983)	(1985)	Maximum 24-h Conc. ($\mu g/m^3$) (1983)	(1985)	Sampler Height (m)	Distance to Nearest Roadway (m)	Nearest Major Roadway Traffic Volume (veh./day)
50109	Montreal	Duncan/Décarie	0.72	0.50	1.8	1.5	4	20	100 000
50601	Rouyn	Hotel de Ville	0.41	0.25	7.7	2.1	8	--	--
60403	Toronto	Evans/Arnold	0.46	0.39	1.7	1.0	2	120	150 000
60412	Toronto	Bathurst/Wilson	0.45	0.45e	1.6	1.2	2	50	225 800
60501	Hamilton	Barton/Sanford	0.40	0.27	2.5	1.1	4	18	18 650
61501	Kitchener	Edna/Frederick	0.52	0.39	2.2	1.6	4.5	20	56 000
90204	Calgary	316-7th Avenue	0.43	0.27	2.2	1.4	9	25	16 150
00104	Vancouver	27th/Ontario	0.50	0.35	1.8	1.2	18	200	10 800
00106	Vancouver	2294 W. 10th	0.41	0.43	1.3	1.7	17	100	30 000
00109	Vancouver	970 Burrard	0.56	0.54	1.9	1.3	4	20	21 200
00114	Vancouver	Mun. Hall (Richmond)	0.46	0.39	2.1	1.3	15	100	29 000
00117	Vancouver	BCIT Burnaby	0.51	0.52	2.2	2.3	18	200	35 000
00303	Victoria	1250 Quadra	0.45	0.36	2.3	1.3	12	18	12 000

* only NAPS stations with complete data record included.
e estimated value.

8 SOILING INDEX

The soiling index is a measurement of the soiling or darkening potential of fine particulate in the atmosphere, measured in coefficient of haze (COH) units. No NAAQOs have been set for this pollutant. Likely sources of fine particulate are: fuel combustion, industrial processes, vehicle exhaust, forest fires, agricultural burning and other fugitive dust emissions.

As shown in Figure 24 and the Appendix, the composite average of the station annual means has come down between 1974 and 1985. The decrease from 0.38 units in 1974 to 0.28 units in 1985 is approximately 25%. Reduced levels at the stations in traditionally more polluted sites accounted for most of the decrease in the average values.

Despite the general improvement in average soiling index levels, statistical analysis (Wilcoxon) of changes between consecutive years has shown that no significant change was indicated except for the decreases that occurred in 1980 and 1983 (Table 3). The distribution of annual means for 1980 and 1983 in Figure 24 shows less spread from the 75th to the 25th percentile than other years.

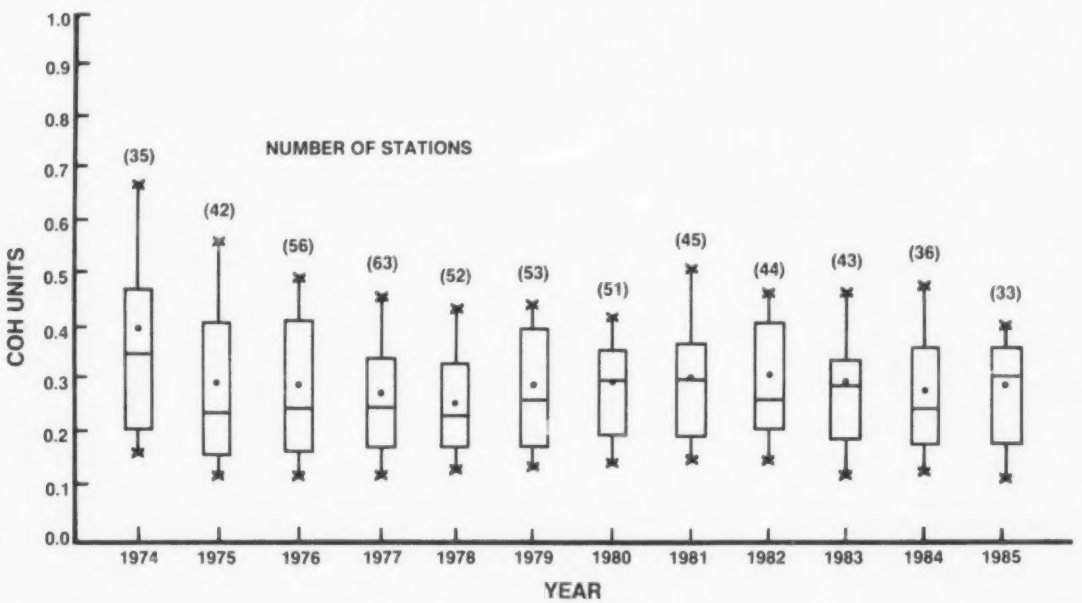


FIGURE 24 SOILING INDEX - DISTRIBUTION OF STATION ANNUAL MEAN DATA (1974-1985)

Long-term changes using Tukey's test in average annual mean soiling index values for Class I stations and for all NAPS network stations are shown in Figure 25. Better agreement at the annual mean level has occurred between Class I Stations and All Stations in recent years. The Class I Stations do, however, tend to show higher index values than do All Stations; this is consistent with their central urban locations. The results of Tukey's test for All Stations indicate that significant (95% confidence) changes in the levels of COH have occurred between 1974 and the years 1977, 1978, 1980, and 1983 to 1985. For the period 1976 to 1985 no significant change is noted as all the confidence limits overlap.

The previously reported (2) occurrence of higher soiling index values in stations in such cities as Montreal, Toronto, Hamilton, Windsor and Vancouver continues. The Barton and Sanford (60501C) station in Hamilton reported the highest annual mean in 1985 (0.52 COH units). One station that consistently records a high annual mean value is the Toronto station at Bathurst and Wilson (60412R) with levels of 0.60 COH units. This station is located near a major expressway (Hwy. 401).

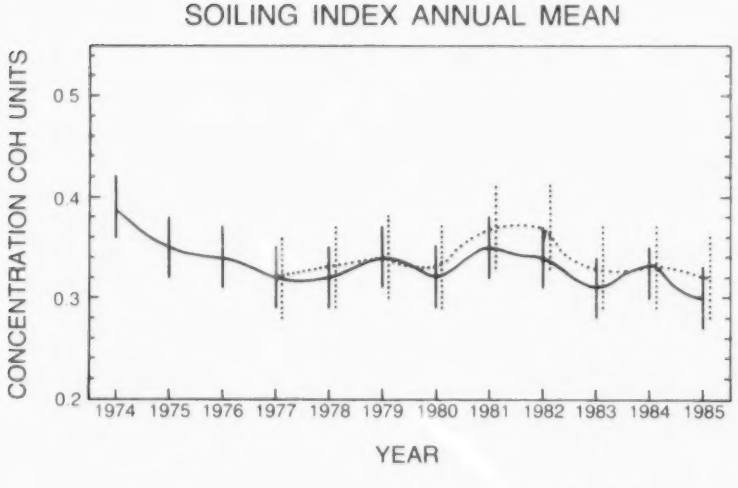


FIGURE 25 TRENDS IN SOILING INDEX ANNUAL MEAN VALUES FOR ALL STATIONS (—) AND CLASS I STATIONS (...) (1974-1985) WITH 95% CONFIDENCE LIMITS

9 ANNUAL AIR QUALITY INDEX

9.1 Basis of the Air Quality Index

An annual air quality index reduces complex and voluminous air monitoring data for numerous air contaminants to a single number which can be used to give some indication of overall air quality. The National Ambient Air Quality Objectives are used to provide a common scale with which to quantify the effects of different pollutants on the quality of the air. Conceptual details and guidelines on the use of the index have been published elsewhere (7); only the main assumptions will be summarized here:

a) the index is based on SO_2, NO_2, CO, O_3 and TSP data from Class I monitoring stations;

b) the index is based on the average of three different pollutant subindicies that have the most significant effect on air quality;

c) at the defined levels, the effects of all pollutants are equally significant with respect to the quality of the air;

d) the index is based on the measured levels of air quality that are not exceeded by more than 2% of readings taken as recommended by the World Health Organization; and

e) if more than one index can be computed for a given pollutant, the largest index is used to represent that pollutant.

Because of these various assumptions, the index can be described as "severe", in that it is based upon 98th percentile concentrations and the largest index computed, rather than on average conditions.

9.2 Air Quality Indices (1977-1983)

Calculated annual air quality index values for all Class I Stations in operation during the 1977-1983 period are summarized in Table 7. A qualitative descriptor (Good, 0-25; Fair, 25-50; and Poor, 50+) has been assigned to each station based on 1977-1985 data. Individual stations are showing some year-to-year variations, and the trends are toward more cleaner sites. For example, the three sites that were rated as "Poor" in 1981 have shown considerable improvement and are now in the "Fair" category.

The majority of the sites may be categorized as "Fair". Eight sites registered an index value of less than 25 (Good) for each of the past two years (1984-1985). Thirteen sites registered in the good category in 1985. By inspection it is evident that the number of "good" stations are increasing over time.

TABLE 7 INDEX OF AIR QUALITY FOR CLASS I STATIONS (1977-1985)

City	Number	Station	1977	1978	1979	1980	1981	1982	1983	1984	1985	Category
Halifax	30116C	Barrington and Duke	22	22	26	26	27	14	21	18	14	G
Saint John	40202C	Post Office	--	--	--	37	34	34	23	31	21	
Montreal	50115C	Peel and Maisonneuve*	45	50	46	51	50	--	25	27	24	
	50116R	3161 Joseph, Verdun	--	--	39	35	36	34	39	36	22	
	50102R	Jardin Botanique	39	37	34	35	26	26	22	24	17	G
	50109C	Duncan and Decarie	43	49	51	50	47	45	46	37	40	
	50112C	Boul. Laurentides	--	35	30	26	29	37	31	24	23	G
	50110C	Parc Pilon, Mtl-Nord	--	--	31	34	36	37	26	35	25	
Hull	50203R	Gamelin and Joffre	--	20	28	19	20	28	22	22	25	G
Quebec City	50307C	Parc Cartier Breboeuf	--	--	--	--	--	--	--	21	22	G
Ottawa	60101C	88 Slater Street	42	39	38	35	24	40	33	34	28	
Windsor	60204C	471 University	46	46	33	43	42	40	39	42	40	
Toronto	60417C	26 Breadalbane Street	40	43	44	42	41	33	40	42	27	
	60412R	Bathurst and Wilson	44	42	45	38	39	40	29	38	--	
	60410R	Lawrence and Kennedy	37	40	40	35	41	34	40	38	26	
	60413R	Queensway W. and Hurontario	--	40	40	38	43	34	40	35	33	
	60402R	Don Mills,Science Centre	--	--	31	31	33	27	30	33	20	
	60413R	Elmcrest Road	36	41	34	34	38	37	39	38	44	
Hamilton	60501C	Barton and Sanford	51	51	48	40	43	46	45	42	37	
London	60901C	King and Rectory	44	42	44	42	41	40	36	38	34	
St. Catharines	61301C	North and Geneva	46	42	38	33	40	35	43	35	34	
Kitchener	61501C	Edna and Frederick	41	47	41	41	43	38	43	37	27	
Winnipeg	70119C	65 Ellen Street	--	39	40	53	39	27	32	36	37	
	70118R	Jefferson and Scotia	34	28	44	41	35	27	28	26	19	G
Regina	80109C	1620 Albert Street	--	--	40	41	52	35	33	43	34	
Edmonton	90130C	10255-104th Street	48	48	53	48	43	49	34	42	35	
	90122R	127 St. and 133 Avenue	39	41	45	39	39	39	38	25	34	
Calgary	90227C	1611-4th Street S.W.	48	49	56	32	29	30	29	24	23	G
	90222R	39 St. and 29 Ave. N.W.	36	35	37	46	36	38	33	32	33	
Vancouver	00112C	Robson and Hornby	36	32	37	31	42	21	18	24	29	
	00106R	2294 West 10th Avenue	36	34	40	27	30	24	23	24	27	
	00108I	250 West 70th Avenue	40	36	42	33	34	35	29	31	36	
	00110R	E. Hastings and Kensington	33	36	36	26	23	19	18	20	20	G
	00111I	Rocky Pt. Park	--	26	32	40	43	26	25	22	27	
Victoria	00303C	1250 Quadra St.	29	23	23	18	22	21	17	27	27	

* After 1980, this station was moved to Metcalfe and Maisonneuve.

Index	Category
0 - 25	Good
26 - 50	Fair
51 - 100	Poor
100+	Very Poor

Note: Because most of the stations fall into the "Fair" category only good stations are designated.

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APPENDIX

SUMMARY DATA - NATIONAL URBAN AIR QUALITY TRENDS 1974-1985

TABLE A SULPHUR DIOXIDE - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL MEAN (1974-1985)

Period	Number of Stations			
	Decrease	Increase	No change **	Total
1974-75*	11	2	10	23
1975-76	7	4	18	29
1976-77	11	9	20	40
1977-78*	22	8	24	54
1978-79	14	7	38	59
1979-80	15	16	35	66
1980-81*	11	5	25	41
1981-82	15	9	19	43
1982-83*	19	5	25	49
1983-84	13	5	25	43
1984-85	14	3	28	45

* statistically, there was a significant change in sulphur dioxide levels (Wilcoxon)

** includes differences of 1.0 ppb to ensure changes are not due to monitoring instrument inaccuracies or other errors

TABLE B SULPHUR DIOXIDE - PERCENTAGE OF STATIONS WITH READINGS IN VARIOUS RANGES WITH RESPECT TO THE NATIONAL AMBIENT AIR QUALITY OBJECTIVES (1974-1985)

Range (ppb)	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
A) Annual Means												
0 to 11*	41	53	54	59	68	67	65	75	84	89	91	96
12 to 23**	41	36	36	36	25	29	34	23	14	9	9	4
> 23	18	11	10	5	7	4	1	2	2	2	-	-
No. of stations	27	36	48	59	71	69	65	51	59	60	55	56
B) 24-hour Maximum												
0 to 60*	60	59	56	54	42	41	57	49	59	65	63	62
61 to 110**	25	24	29	24	44	44	36	38	35	21	29	33
111 to 310***	15	17	15	21	13	15	6	12	4	10	8	5
>310	--	--	--	1	1	--	1	1	2	4	-	-
No. of stations	55	63	75	83	92	90	89	82	81	78	75	73
C) 1-hour Maximum												
0 to 170*	56	57	56	59	61	62	74	55	64	73	67	73
171 to 340**	31	21	33	23	22	27	16	30	27	17	24	19
>340	13	22	11	18	17	11	11	15	9	10	9	8
No. of stations	55	63	75	83	92	89	88	82	81	78	75	73

* desirable level

** acceptable level

*** tolerable level

TABLE C NITROGEN DIOXIDE - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL MEAN (1977-1985)

Period	Number of Stations			
	Decrease	Increase	No change**	Total
1977-78	8	9	4	21
1978-79*	12	4	7	23
1979-80	15	6	10	31
1980-81	8	6	17	31
1981-82	9	9	13	31
1982-83*	14	1	15	30
1983-84*	3	12	13	28
1984-85	10	8	18	36

* statistically, the change in levels was significant at 95% confidence (Wilcoxon)

** includes stations having differences of 1.0 ppb to ensure changes are not due to monitoring instrument inaccuracies or other errors

TABLE D NITROGEN DIOXIDE - PERCENTAGE OF STATIONS IN VARIOUS RANGES WITH RESPECT TO NATIONAL AMBIENT AIR QUALITY OBJECTIVES (1977-1985)

Range (ppb)	1977	1978	1979	1980	1981	1982	1983	1984	1985
A) Annual Means									
0 to 32*	59	64	76	78	86	86	97	87	90
33 to 53**	37	36	24	22	14	14	3	13	10
> 53	4	---	---	---	---	---	---	---	---
No. of stations	27	33	34	37	36	38	33	39	41
B) 24-hour Maximum									
0 to 110**	84	87	92	90	90	92	92	96	96
111 to 160***	16	13	8	10	8	8	8	4	4
>160	---	---	---	---	2	---	---	---	---
No. of stations	44	47	49	50	49	49	50	51	51
C) 1-hour Maximum									
0 to 210**	86	87	96	92	86	84	96	98	100
211 to 530***	14	13	2	8	14	16	4	2	---
>530	---	---	2	---	---	---	---	---	---
No. of stations	44	47	49	50	49	49	50	51	51

* desirable level
** acceptable level
*** tolerable level

TABLE E CARBON MONOXIDE - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL MEAN (1974-1985)

Period	Number of Stations			
	Decrease	Increase	No change**	Total
1974-75*	9	3	3	15
1975-76	7	9	3	19
1976-77	8	7	9	24
1977-78	8	9	11	28
1978-79	9	10	13	32
1979-80*	17	6	14	37
1980-81	5	8	19	32
1981-82*	13	1	18	32
1982-83	11	3	21	35
1983-84*	15	2	22	39
1984-85	10	4	28	42

* statistically, there was a significant change in carbon monoxide levels (Wilcoxon)

** includes stations where differences were 0.1 ppm to ensure changes are not due to monitoring instrument inaccuracies or other errors

TABLE F CARBON MONOXIDE - PERCENTAGE OF STATIONS WITH READINGS IN VARIOUS RANGES WITH RESPECT TO NATIONAL AMBIENT AIR QUALITY OBJECTIVES (1974-1985)

Range (ppm)	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
A) 8-hour Maximum												
0 to 5.0*	11	6	14	17	21	18	23	13	15	25	24	36
5.1 to 13**	60	67	70	73	71	63	69	73	74	71	72	58
13.1 to 17***	22	18	14	6	6	14	4	12	6	-	2	4
>17 7	9	2	4	2	6	4	2	5	4	2	2	2
No. of stations	27	33	42	48	52	51	52	52	53	51	54	55
B) 1-hour Maximum												
0 to 13*	30	18	32	31	42	39	59	46	51	59	59	65
13.1 to 31**	67	76	63	65	56	55	38	46	42	37	39	33
>31 3	6	5	4	2	6	3	8	7	4	2	2	2
No. of stations	27	33	42	48	52	51	52	52	53	51	54	55

* desirable level
** acceptable level
*** tolerable level

TABLE G OZONE - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL MEAN (1979-1985)

Period	Number of Stations			
	Decrease	Increase	No Change**	Total
1979-80	10	9	15	34
1980-81*	13	4	15	32
1981-82*	3	12	17	32
1982-83	5	10	16	31
1983-84	6	5	15	31
1984-85	4	9	18	31

* statistically significant change in annual mean levels (Wilcoxon)

** includes stations with differences of 1.0 ppb to ensure changes are not due to monitoring instrument inaccuracies or other errors

TABLE H OZONE - PERCENTAGE OF STATIONS WITH READINGS IN VARIOUS RANGES WITH RESPECT TO NATIONAL AMBIENT AIR QUALITY OBJECTIVES (1979-1985)

Range (ppb)	1979	1980	1981	1982	1983	1984	1985
A) Annual Means							
0 to 15**	50	46	54	45	39	41	40
> 15	50	54	46	55	61	59	60
Number of stations	38	41	35	40	36	34	42
B) 1-hour Maximum							
0 to 50*	2	4	6	4		4	4
51 to 80**	16	22	26	25	34	40	45
81 to 150***	62	68	58	69	58	52	47
>150	20	6	10	2	8	4	4
Number of stations	45	50	50	49	50	52	51

* maximum desirable
** maximum acceptable
*** maximum tolerable

TABLE I SUSPENDED PARTICULATE - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL MEAN (1974-1985)

Period	Number of Stations			
	Decrease	Increase	No change**	Total
1974-75*	30	9	12	51
1975-76	14	17	23	54
1976-77*	23	13	31	67
1977-78	26	12	36	74
1978-79*	14	40	31	85
1979-80*	17	34	33	84
1980-81*	42	4	28	74
1981-82*	43	5	22	70
1982-83*	39	10	29	78
1983-84	18	14	40	72
1984-85*	33	9	33	75

* statistically, there was a significant change in the annual geometric mean (Wilcoxon)

** includes stations with differences up to 4 $\mu g/m^3$ to ensure changes are not due to monitoring instrument inaccuracies or other errors

TABLE J SUSPENDED PARTICULATE - PERCENTAGES OF STATIONS WITH READINGS IN VARIOUS RANGES WITH RESPECT TO NATIONAL AMBIENT AIR QUALITY OBJECTIVES (1974-1985)

Range ($\mu g/m^3$)	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
A) Annual Geometric Means												
0 to 60*	32	47	45	50	56	48	44	61	80	81	79	92
61 to 70**	19	11	18	26	17	18	22	21	8	9	12	6
>70	49	42	37	24	27	34	34	18	12	10	9	2
No. of stations	59	60	76	83	95	95	101	87	93	88	86	88

* desirable level

** acceptable level

TABLE K LEAD - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL MEAN (1974-1985)

Period	Number of Stations			
	Decrease	Increase	No change **	Total
1974-75*	23	3	23	49
1975-76*	19	3	20	42
1976-77*	18	3	26	47
1977-78*	30	7	18	55
1978-79*	28	6	22	56
1979-80*	30	6	33	69
1980-81	19	10	29	59
1981-82*	32	2	31	65
1982-83	27	6	33	66
1983-84	17	7	42	66
1984-85*	24	7	38	69

* indicates year where a significant change in annual levels occurred (Wilcoxon)

** includes stations with differences up to 0.04 $\mu g/m^3$ to ensure changes are not due to monitoring instrument inaccuracies or other errors

TABLE L SOILING INDEX - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL MEAN (1974-1985)

Period	Number of Stations			
	Decrease	Increase	No change**	Total Pairs
1974-75	12	10	5	27
1975-76	16	16	7	39
1976-77	16	12	19	47
1977-78	21	13	18	52
1978-79	18	20	15	53
1979-80*	21	12	9	42
1980-81*	4	16	17	37
1981-82	14	12	11	37
1982-83	15	6	7	28
1983-84	11	10	8	29
1984-85	12	5	7	24

* indicates year where a significant change in annual levels occurred (Wilcoxon)

** includes stations with differences of 0.01 COH units to ensure changes are not due to monitoring instrument inaccuracies or other errors

TABLE M SUMMARY DATA - - URBAN AIR QUALITY IN CANADA, 1974-1985

Pollutant	Year	Number of Sites	Average of Annual Mean	Percentage of Sites with Annual Mean Lower than Given Values				
				90%	75%	50%	25%	10%
SO_2 (ppb)	1974	27	13	27	22	12	2	0
	1975	36	11	23	18	10	2	0
	1976	49	12	24	19	10	4	0
	1977	59	11	23	15	10	3	0
	1978	71	10	20	13	9	4	1
	1979	69	10	16	12	8	5	0
	1980	65	9	16	13	9	4	1
	1981	51	8	14	11	5	4	1
	1982	59	8	12	10	7	4	2
	1983	59	6	11	8	5	3	1
	1984	55	7	11	9	6	4	1
	1985	56	6	10	9	6	2	1
NO_2 (ppb)	1977	27	31	44	39	27	21	19
	1978	33	29	40	35	29	20	18
	1979	34	26	34	31	27	19	12
	1980	38	25	37	31	23	19	11
	1981	36	23	32	29	22	16	11
	1982	38	23	34	27	22	18	10
	1983	33	22	29	26	23	18	12
	1984	38	24	34	27	23	18	15
	1985	41	22	29	26	22	17	12
CO (ppm)	1974	18	2.4	5.0	3.0	2.2	1.2	0.7
	1975	22	1.9	2.8	2.4	1.7	1.3	0.8
	1976	29	1.6	2.4	1.9	1.4	0.9	0.7
	1977	33	1.6	2.3	1.9	1.4	0.9	0.5
	1978	40	1.5	2.8	2.0	1.3	0.8	0.5
	1979	42	1.7	3.2	2.0	1.5	1.0	0.8
	1980	43	1.5	2.8	1.8	1.4	0.9	0.6
	1981	36	1.5	2.3	1.6	1.4	0.9	0.5
	1982	41	1.3	2.2	1.9	1.2	0.9	0.5
	1983	43	1.2	2.1	1.4	1.0	0.7	0.5
	1984	49	1.1	1.8	1.3	0.9	0.5	0.5
	1985	45	1.0	1.8	1.3	0.9	0.5	0.5
Ozone (ppb)	1979	39	15	20	18	15	12	10
	1980	41	16	21	20	16	12	9
	1981	35	15	20	18	15	12	10
	1982	40	16	21	19	16	13	10
	1983	36	16	21	14	10	7	5
	1984	36	16	20	19	17	12	10
	1985	42	17	23	19	16	13	11
SP ($\mu g/m^3$)	1974	59	78.6	121.0	96.0	70.0	53.0	43.0
	1975	59	65.9	98.0	77.0	61.0	51.0	39.0
	1976	76	65.7	91.0	78.0	64.0	50.0	43.0
	1977	83	61.9	93.0	69.0	61.0	48.0	39.0
	1978	91	61.4	92.0	68.0	53.0	44.0	36.0
	1979	96	66.0	99.0	78.0	60.0	50.0	38.0
	1980	101	67.0	99.0	77.0	64.0	50.0	40.0
	1981	87	58.6	80.0	66.0	56.0	42.0	37.0
	1982	93	51.8	77.0	58.0	49.0	39.0	33.0
	1983	88	47.6	68.0	53.0	43.0	36.0	30.0
	1984	86	46.5	66.0	56.0	42.0	33.0	28.0
	1985	90	42.9	59.0	50.0	42.0	35.0	27.0
Lead ($\mu g/m^3$)	1974	58	0.68	1.22	0.97	0.53	0.26	0.15
	1975	57	0.55	1.00	0.83	0.41	0.23	0.15
	1976	57	0.49	1.00	0.70	0.32	0.17	0.11
	1977	64	0.46	0.89	0.67	0.36	0.19	0.10
	1978	74	0.42	0.75	0.57	0.36	0.23	0.14
	1979	79	0.39	0.72	0.55	0.36	0.21	0.12
	1980	84	0.34	0.60	0.47	0.30	0.17	0.10
	1981	75	0.32	0.62	0.41	0.24	0.17	0.11
	1982	80	0.27	0.53	0.37	0.23	0.14	0.09
	1983	81	0.25	0.45	0.35	0.24	0.14	0.08
	1984	82	0.23	0.44	0.35	0.19	0.11	0.05
	1985	84	0.18	0.39	0.25	0.15	0.10	0.05
Soiling Index (COH)	1974	35	0.38	0.67	0.46	0.34	0.20	0.14
	1975	42	0.28	0.56	0.40	0.23	0.16	0.11
	1976	56	0.28	0.49	0.40	0.24	0.16	0.10
	1977	63	0.27	0.47	0.33	0.24	0.17	0.10
	1978	63	0.25	0.44	0.32	0.22	0.17	0.11
	1979	67	0.28	0.45	0.39	0.26	0.18	0.15
	1980	51	0.28	0.43	0.34	0.28	0.18	0.13
	1981	45	0.30	0.34	0.35	0.29	0.18	0.12
	1982	44	0.30	0.46	0.41	0.26	0.20	0.13
	1983	35	0.28	0.47	0.33	0.27	0.18	0.12
	1984	36	0.27	0.47	0.36	0.23	0.17	0.12
	1985	33	0.28	0.41	0.36	0.30	0.17	0.10